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163

INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

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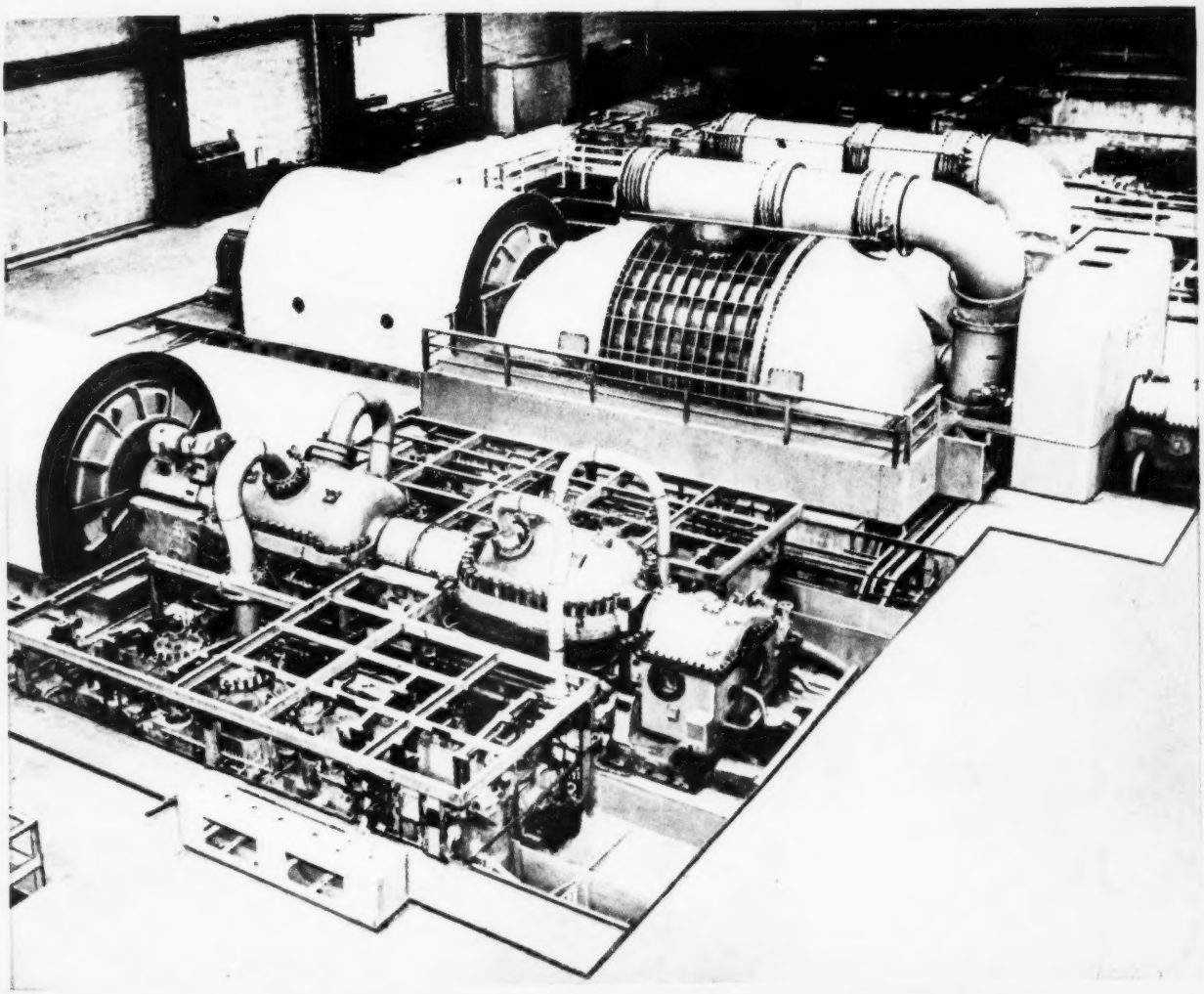

200 MW TURBO-GENERATOR AT RICHARD L. HEARN POWER STATION, TORONTO.

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BUCYRUS

SERVES INDIA'S VITAL PROJECTS

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120 RB Ward Leonard Electric,
54 RB 54 B, 38 B Diesel shovels Etc.

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54 RB Ward Leonard Electric, 43 RB, 37 RB Diesel Shovels etc.

KOSI PROJECT :
54 RB, 19 RB Diesel Draglines etc.

DAMODAR VALLEY CORPORATION :
5 W Diesel with Ward Leonard Electric Swing Walking Draglines, 54 RB 54 B Diesel Draglines, 27 RT Blast Hole Drills etc.

MOR CANAL PROJECT :
10 RB, 19 RB, 33 RB Diesel Shovels, Draglines, Clamshells etc.

HIRAKUD PROJECT :
5w Diesel Walking Draglines, 54 RB Diesel Shovels etc.

MACHKUND HYDEL PROJECT :
38 RB Diesel Shovels, Draglines etc.

NAGARJUNSAGAR CANALS :
22 RB Diesel Tunnel Shovels.

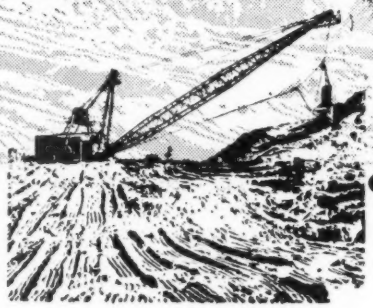
PERIYAR HYDRO ELECTRIC PROJECT :
22 RB and 38 RB Heavy Duty Diesel Shovels, Cranes etc.

TUNGABHADRA HYDEL PROJECT :
33 RB Diesel Shovels, Draglines,
27 RT Diesel Blast hole Drills etc.

MAHI PROJECT :
19, RB Diesel Shovels, Draglines etc.

KOYNA PROJECT :
19 RB Heavy Duty Diesel Tunnel Shovels.

CHAMBAL HYDEL PROJECT :
43 RB Diesel Shovels, Draglines etc.



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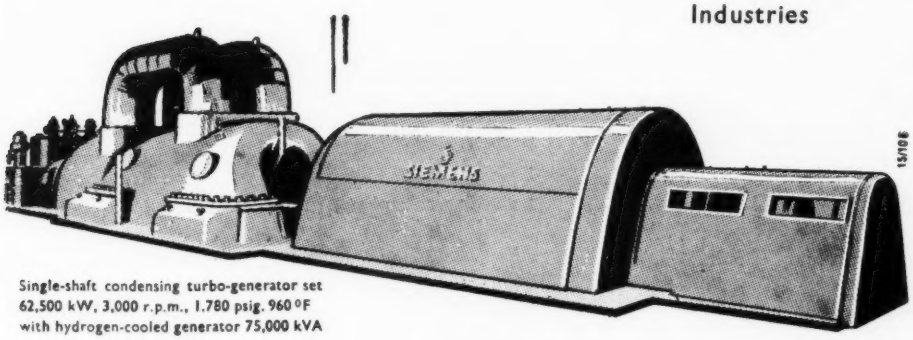

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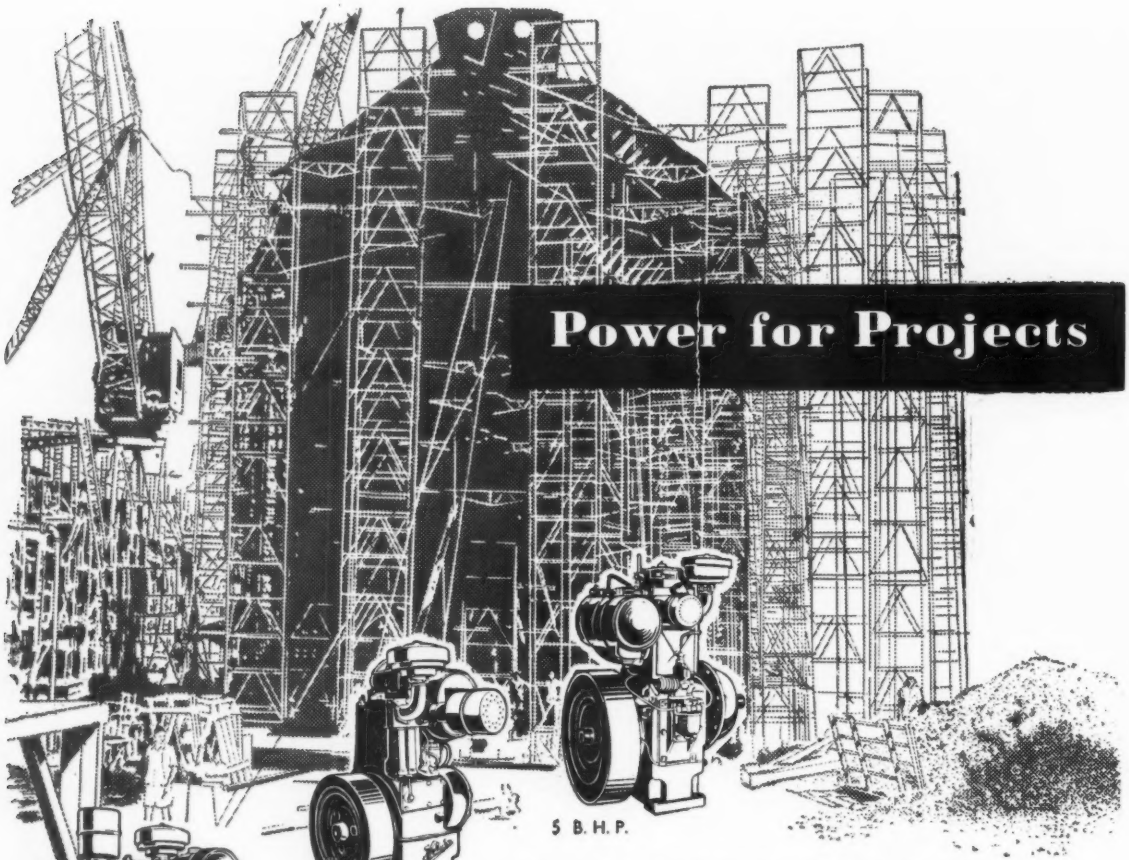

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L-57
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They may be equipped with easily exchangeable attachments for all kinds of digging and loading and with special attachments for crane work, pile driving, etc.

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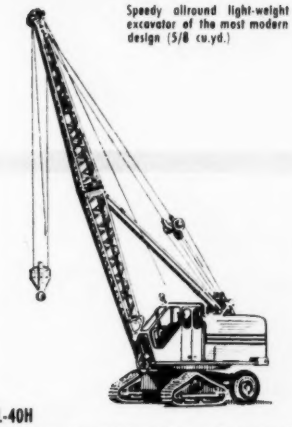
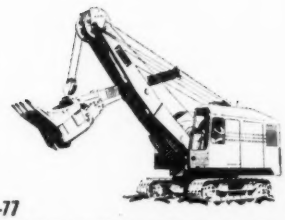
Speedy allround light-weight excavator of the most modern design (5/8 cu.yd.)





L-77
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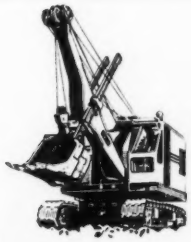

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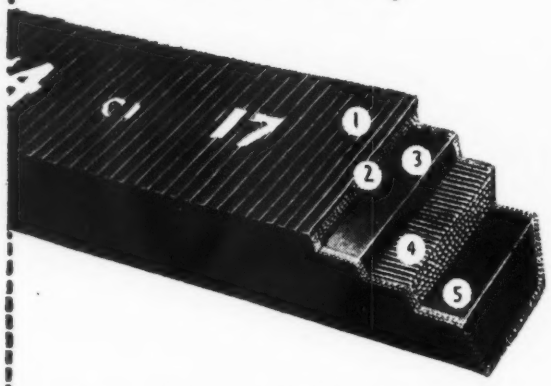

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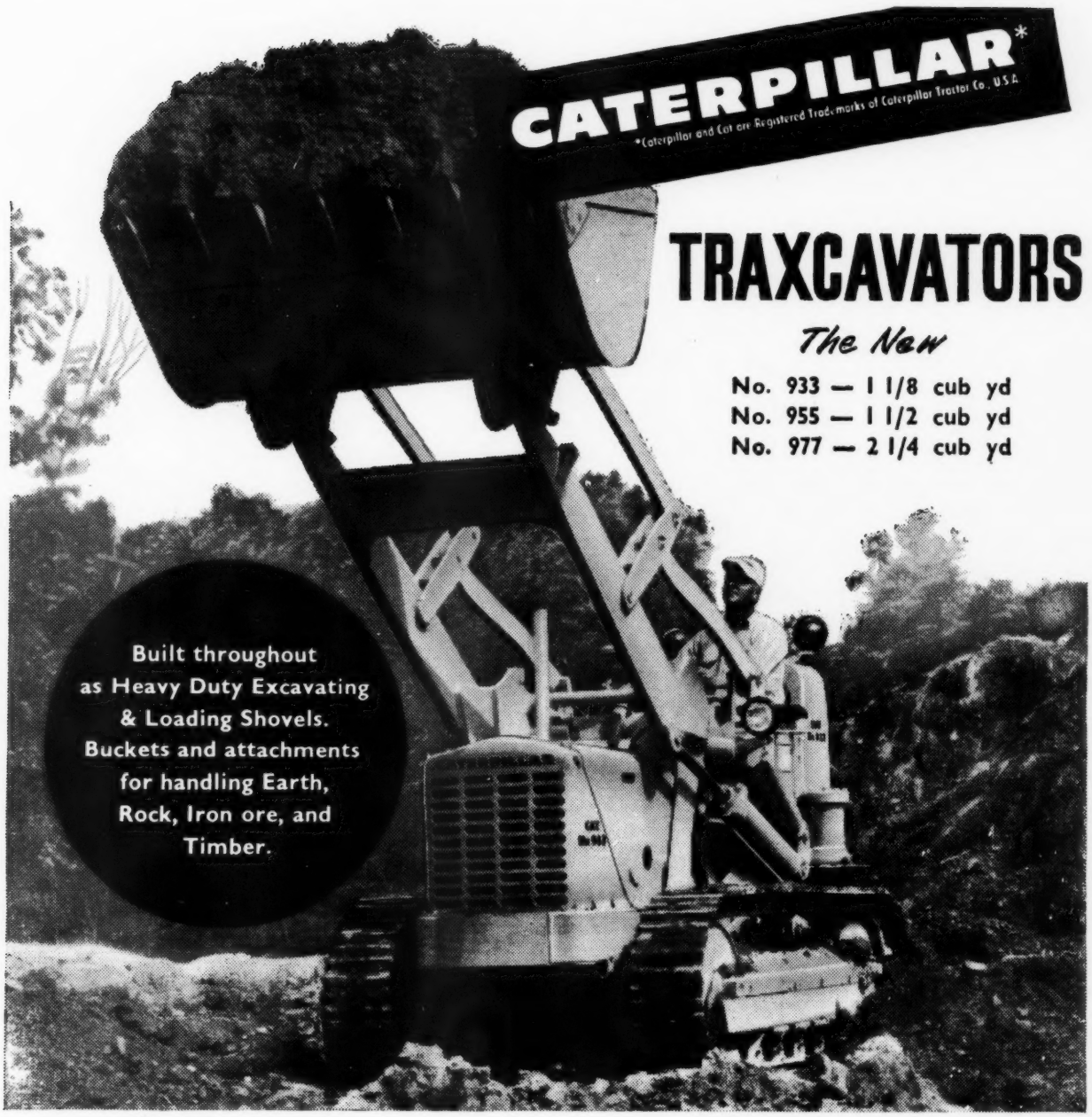
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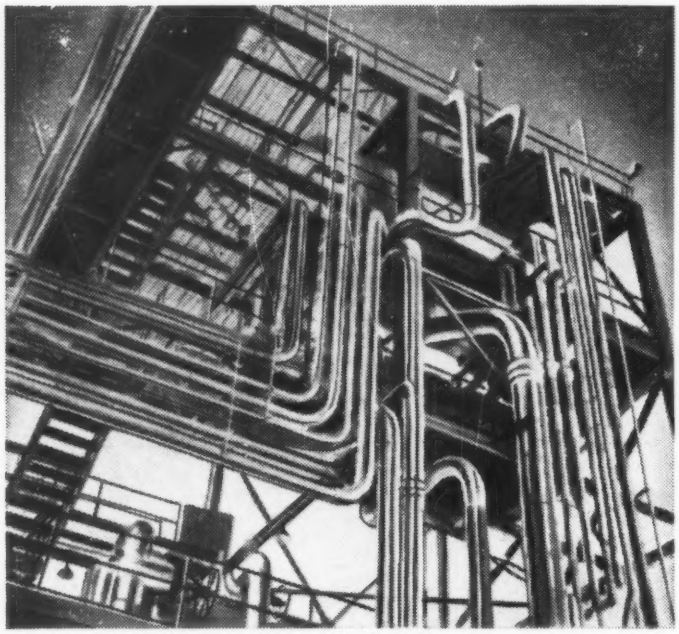

General view of pipework outside the turbine room at Trombay Thermal Power station

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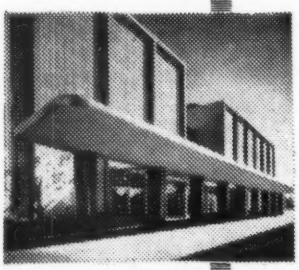

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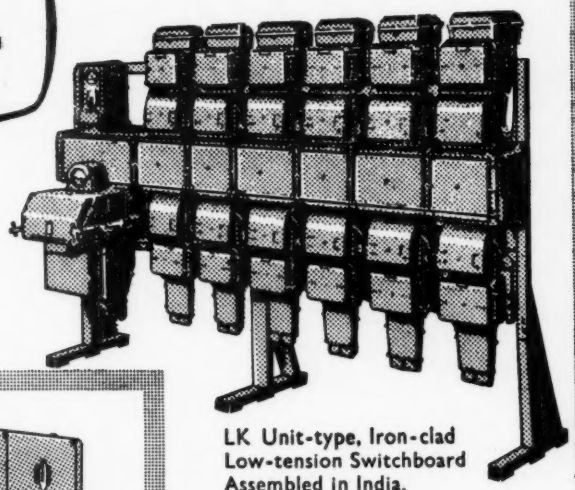

LK Unit-type, Iron-clad
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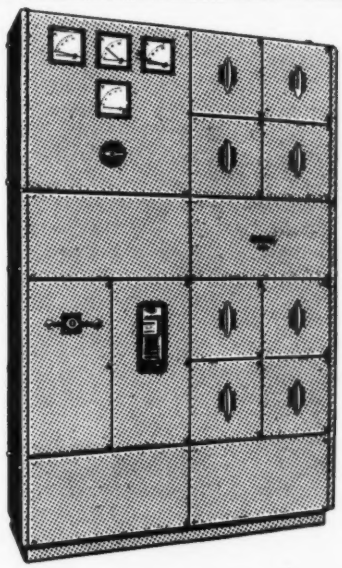

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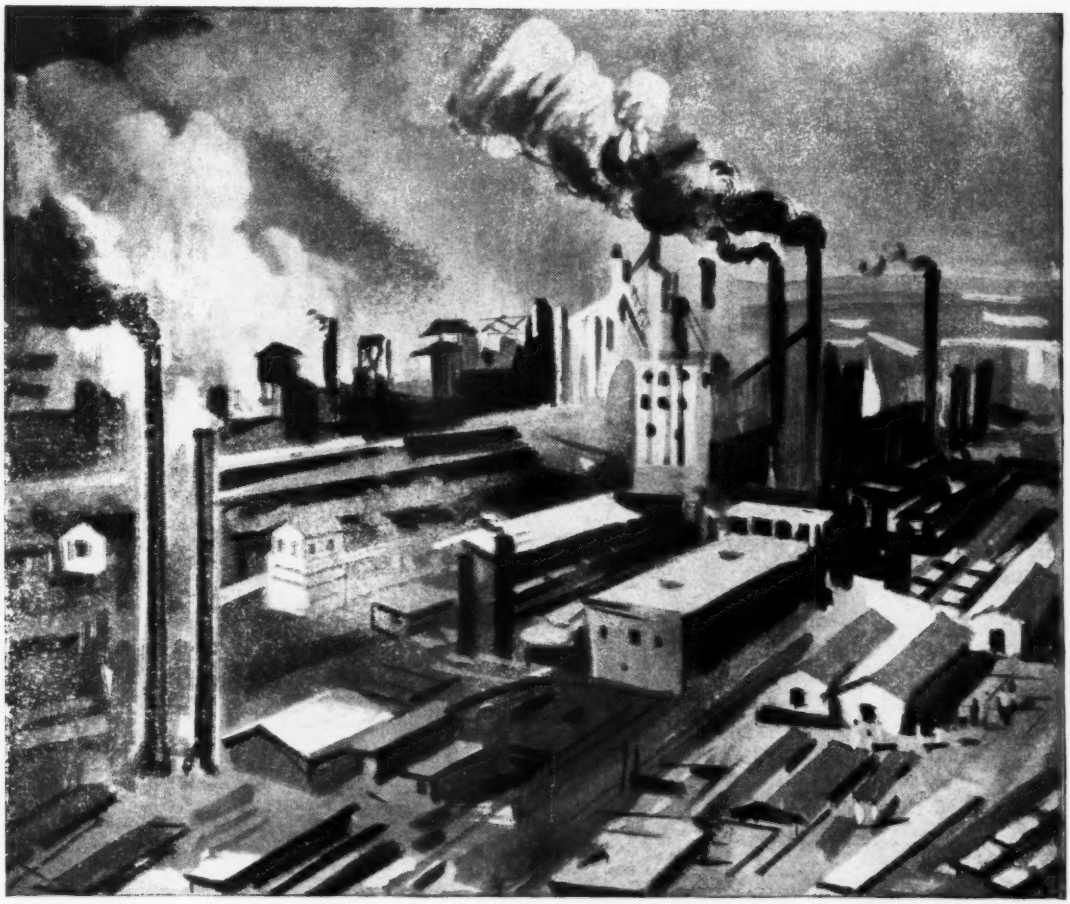

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This is the town that never sleeps—the town of steel. Night and day, the vast works throb with activity as men and machines labour to feed the iron and steel-hungry industries of the nation. Using the most modern production technique the Company manufacture, under a system of rigid quality control, a wide range of products including rails, structurals, blooms, sheets, billets, slabs, pig iron, spun iron pipes, vertically-cast iron pipes and iron, steel and non-ferrous castings.

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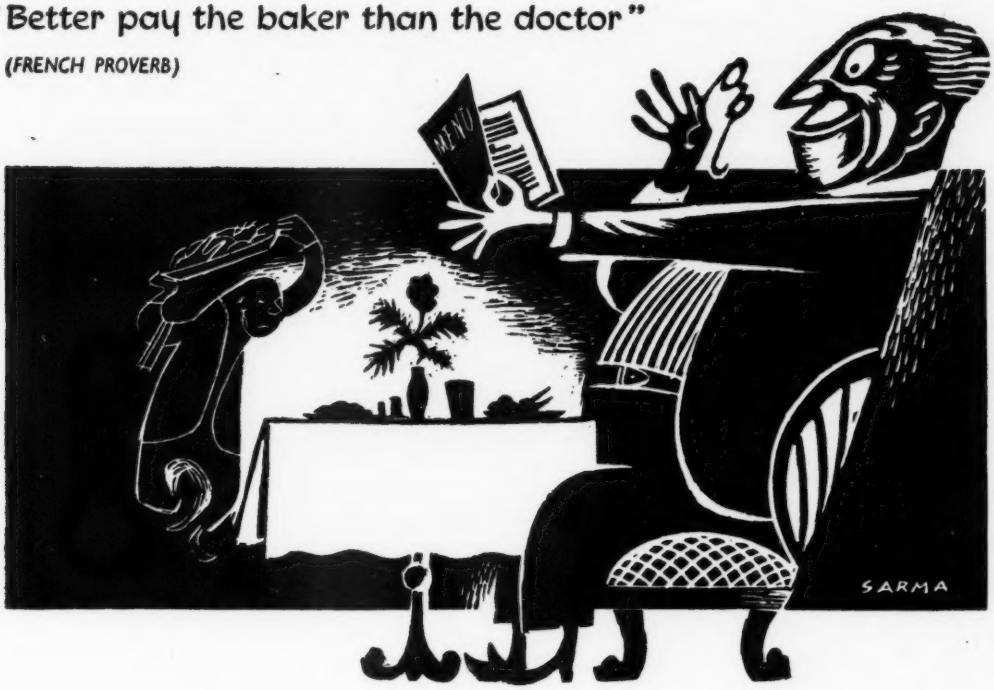
In France they say:

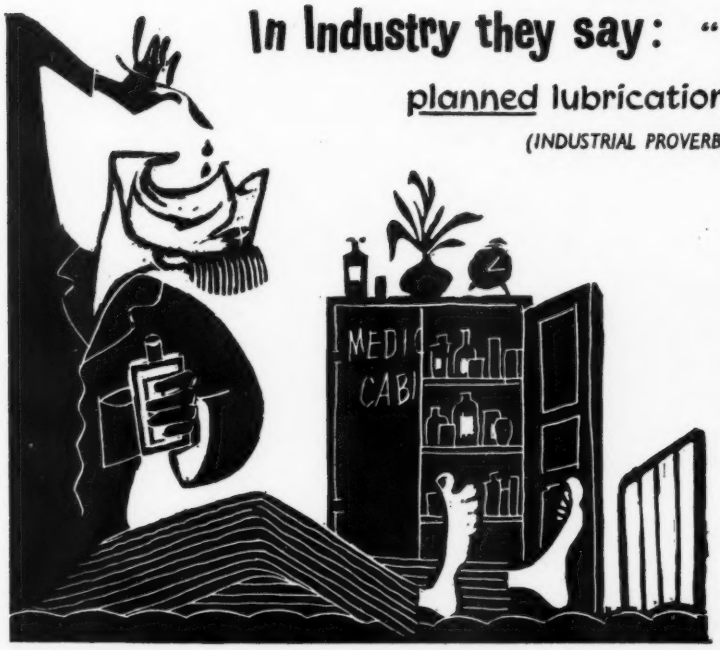
"Better pay the baker than the doctor"

(FRENCH PROVERB)



In Industry they say: "BURMAH-SHELL for planned lubrication"

(INDUSTRIAL PROVERB)



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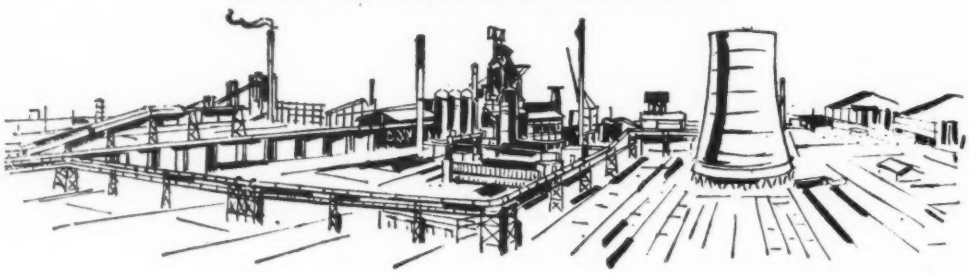

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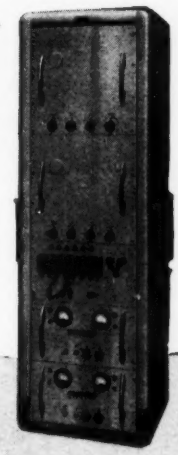

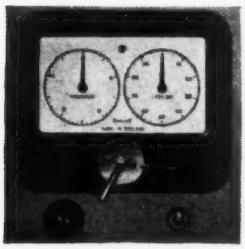

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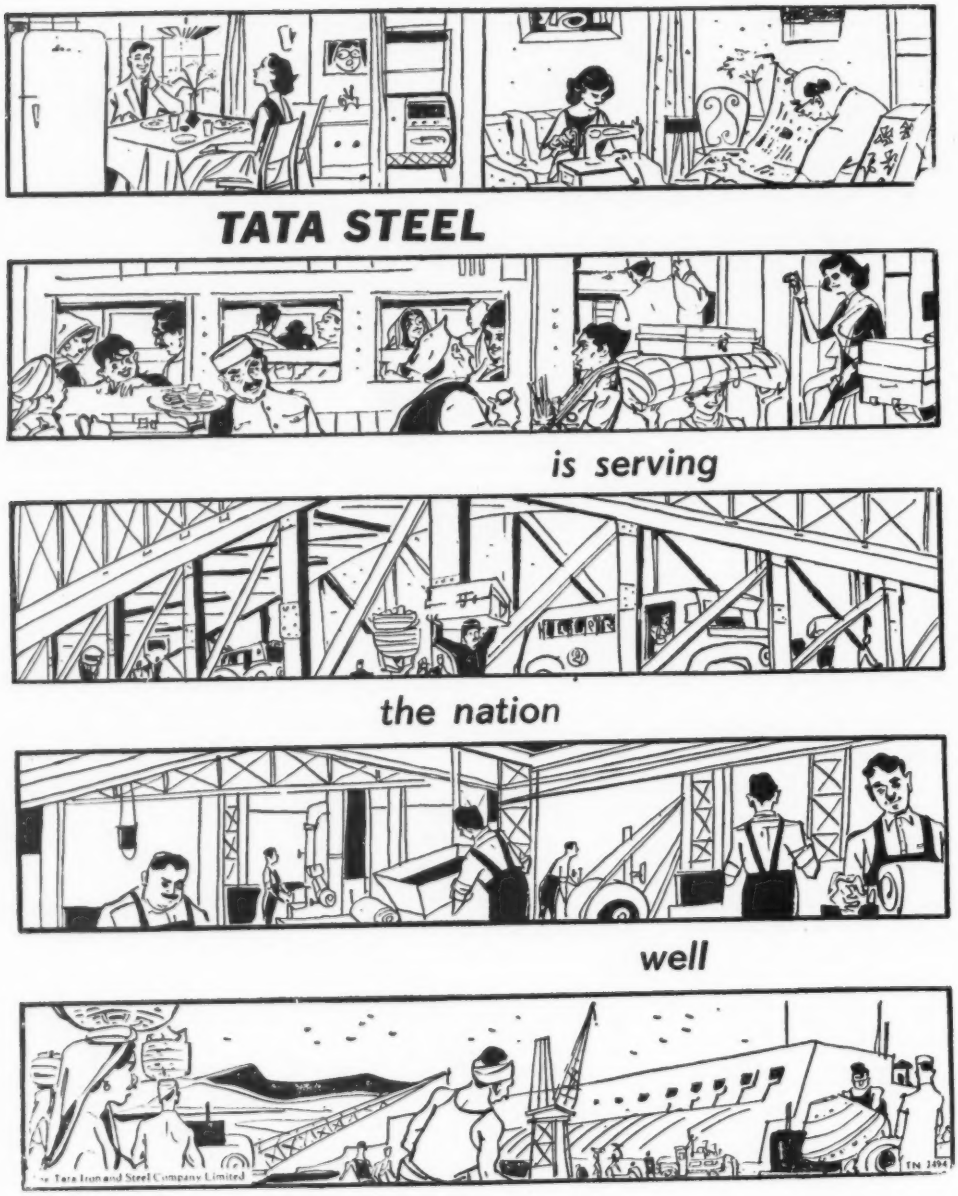
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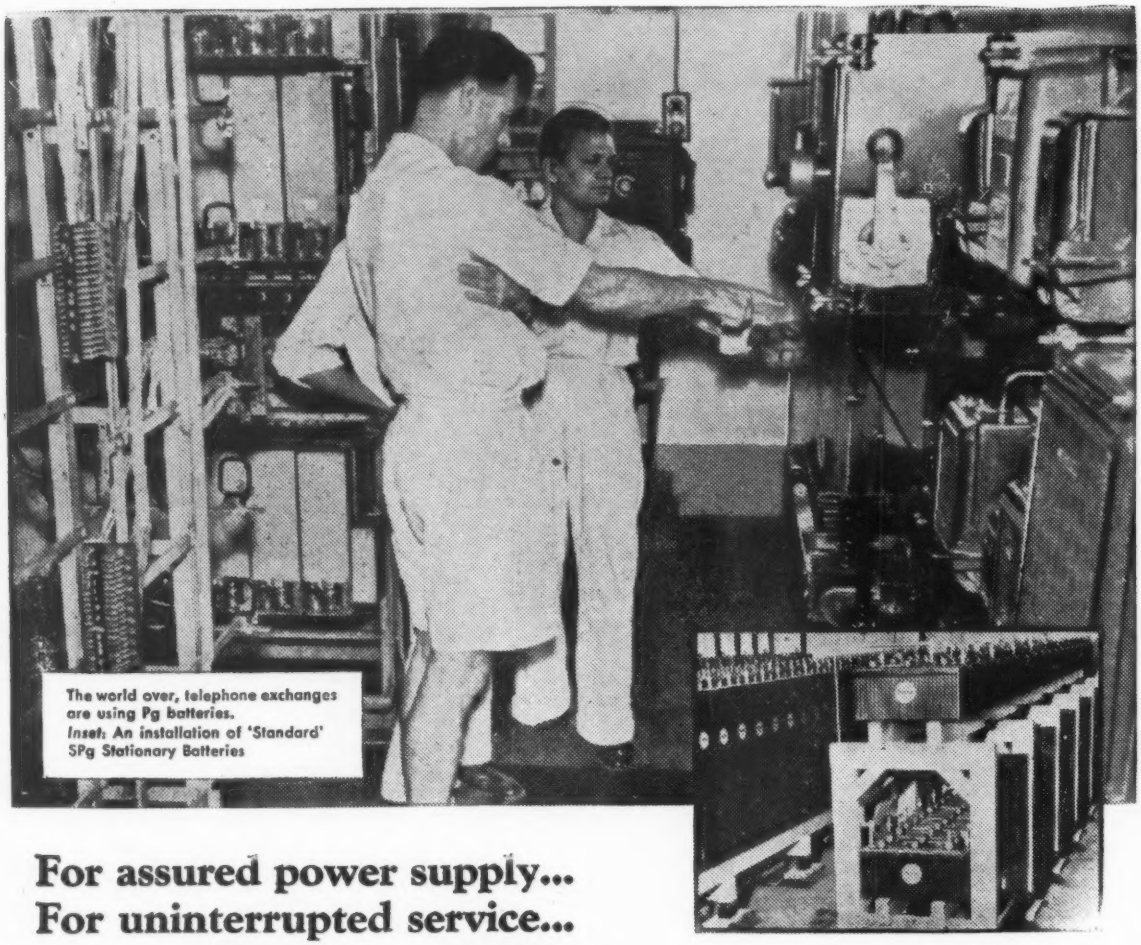

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Inset: An installation of 'Standard' SPg Stationary Batteries

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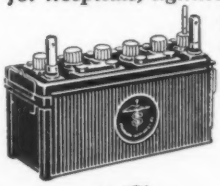

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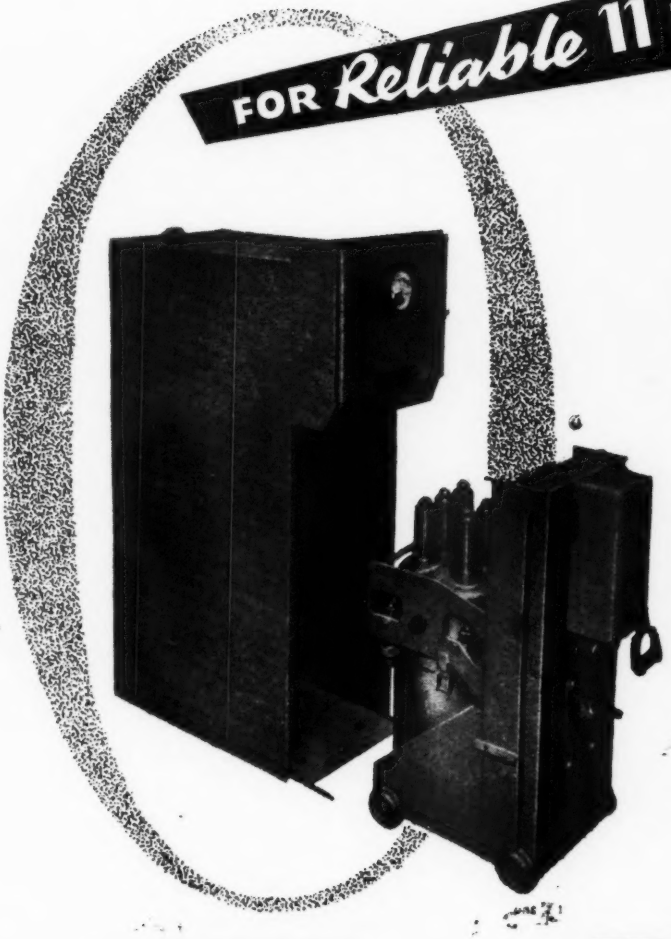

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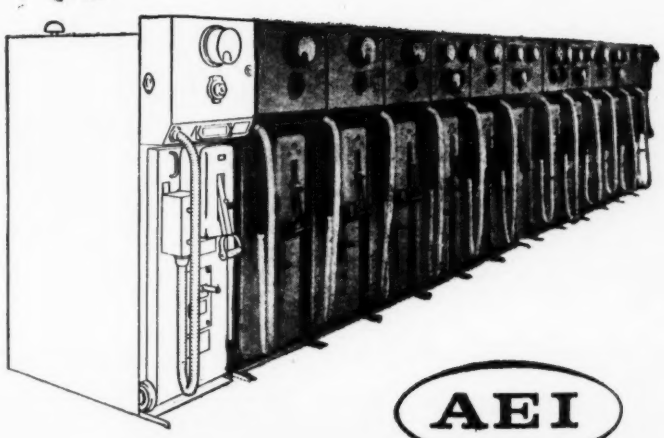

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A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

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6/2, MADAN STREET, CALCUTTA-13. PHONES : 23-1765 & 23-5855. GRAMS : TEKJOURN
Manager : B. Bhattacharya

Bombay Office
41, Hamam Street
Bombay 1
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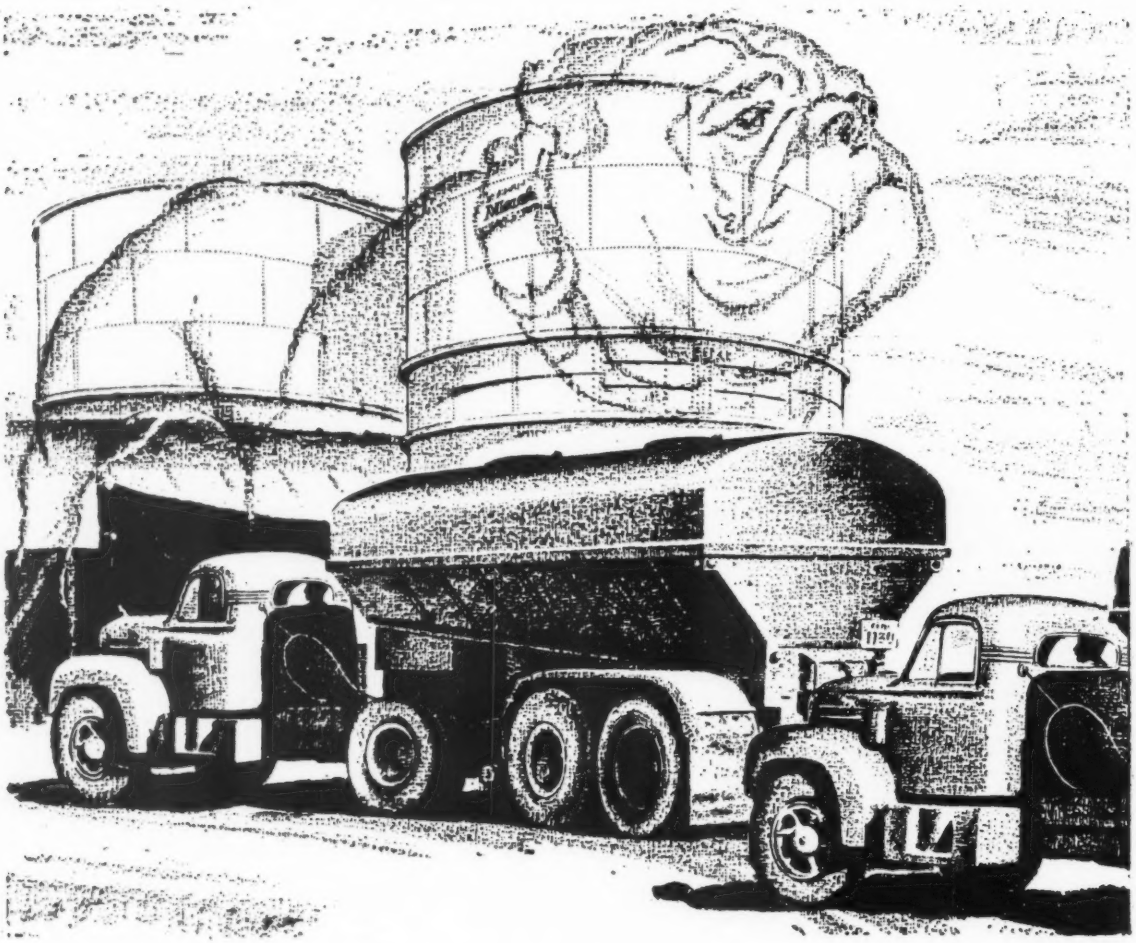

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VOL. 105A.

Financing Policy for Public Utilities

The following are extracts from a speech delivered by the President of the International Bank for Reconstruction and Development before the 27th Session of the Economic and Social Council of the United Nations held in Mexico in April, 1959. It discusses a very important aspect of fiscal policy in the matter of power projects and has interesting reference to the policies pursued in India.

By EUGENE R. BLACK

Members of the Council are aware that most of the money the Bank lends is raised in the world's capital markets. Our rising rate of lending and our growing rate of disbursements on loans have required us to expand our borrowings. The past 12 months, in fact, have been one of the most active marketing periods in our history. We have sold just over $630 million of bonds and notes—three fifths of it outside the United States. One fifth of it was sold for currencies other than United States dollars; and this amount included the sale in Germany just a few days ago of the largest issue of World Bank bonds ever to be offered to the public outside the United States.

The question of the Bank's capital, as you know, has been under study by our Board of Governors. A few weeks ago, the Board voted unanimously to approve a general doubling of the Bank's authorized capital, with certain further addition as well. It remains for the individual member governments to take specific steps to increase their subscriptions; and this action, I am glad to say, has been nearly completed by a number of member countries, including the United States and the United Kingdom. These steps do not, in most cases, call for additional cash payments to the Bank, but they will greatly enlarge the backing for the Bank's borrowings.

A number of other proposals have been made that would provide additional capital for development—among them, proposals for regional institutions here in Latin America and in the Middle East. All in all, the prospects are good that the amount of public capital available for international assistance to development will continue to increase.

This circumstance should be a powerful incentive for the developing countries to mobilize their own capital to the fullest possible extent. If there is a strong base in domestic savings, capital from outside may provide the necessary margin of success in the development effort; without it, no amount of international capital is likely to bring lasting success.

The Bank sees this in many aspects of the development process, but nowhere more so than in the field of public utilities. The Bank itself has lent more than $ 3,000 million for power projects, road and rail programs and other public services. This is better than three-quarters of all our development lending. In Latin America, nearly nine-tenths of our investments have been in power and transportation projects. And in all these cases, the Bank's loans provide only part of the prodigious costs involved. Our borrowers have had to invest considerably larger sums out of their own sources of capital.

A steadily expanding supply of essential public utility services is a requisite of economic growth in all underdeveloped countries today. Over the next decade, many thousands of millions of dollars in capital for these services must be found. There is simply no practical way to raise this money unless a substantial part of it is generated by the utilities themselves through adequate charges to the users of their services.

The Bank has been laboring this point for a very long time. We have held that it is dangerous for a developing country to be sentimental or politically expedient about things like railroads and power plants; that policies based on these attitudes only create an intolerable drain on the savings which are the lifeblood of every country's future prosperity. We have said that adequate utility rates are especially important in a country where there is no organized capital market. By "adequate" rates we have meant rates which enable utilities not only to cover the real cost of their services but also the retain out of earnings substantial sums each year to help finance the expansions which inevitably will be needed to sustain future growth. And we have made no distinction in advocating adequate rates between privately-owned and publicly-owned utilities.

We have at times been accused of being unduly rigid, if not even dogmatic in our insistence on these things. But in retrospect I am glad we have been firm. To be equipped financially for the long pull ahead, free governments have no real alternative to allowing their utility managers to set adequate rates —and then to adjust them promptly and proportionately whenever the cost of providing the services increases. There is simply no other way of attracting development capital—domestic and foreign, private and public—to these expensive but indispensable development enterprises.

I feel the Bank's insistence on sound utility finance is being vindicated today by events in many member countries. All over Latin America and in many other parts of the underdeveloped world, officials charged with the job of finding capital for development are themselves struggling to get a recognition of the

simple principle that utilities should pay their way. President Frondizi of Argentina, in explaining his courageous stabilization program recently put the matter bluntly : "The deficits of the State enterprises can be traced to three essential causes: bad organization, excess of administrative personnel, and (utility) tariffs that are below the cost of operating the services. No effort will be spared to achieve a reduction in the costs of these services and an improvement in their economic yield. ."

Similarly, in Brazil, President Kubitschek recently said, "The impossibility of seeking in the investing public, or in the re-investment of profits of the utility itself, resources for the expansion of (utility services) transfers to the public budget or to government banks the whole of the responsibility for financing indispensable expansions, a burden which they will never be able to bear without directly or indirectly resorting to vast issuances of money. The resulting inflation, contaminating the whole economic body of the country, will then be the price to be paid for discouraging the best way of financing public services, i.e., through the users themselves."

Similar statements are being made in Chile and here in Mexico.

In India, today, the government is adopting new regulatory policies for its power utilities and the reason why is very instructive. One of the sources of domestic revenue counted on to finance India's Second Five-Year Plan has been yielding more by a good deal than had been expected. That source is the Indian railroads. The Indian railroads over the duration of the Plan will have contributed, even after allowing for depreciation, the equivalent of half a billion dollars out of operating surpluses. This is no windfall; it is the result of good financial management. Because the Indian railroads do not represent a charge on the government's ordinary budget, because they provide so significantly for their own expansion and modernization from their own revenues, the government will have more resources available for things like schools and public health services. Quite naturally India's development authorities now want to get a similar result from their power utilities.

India's experience shows dramatically how, by relieving the general taxpayer from the burden of utility subsidies, more resources are available for the more human development needs. At bottom every underdevelopedc country faces the same choice : Do you wante subsidized power or do you want more schools ? Do you want a free ride on the railroad or a city sewer system ? These choices may be disguised in a rich country, though they exist there too, but in a poor country they stand out starkly against the scarce supply of savings available for development.

What in many minds has confused this harsh but inescapable choice, of course, is the notion that somehow subsidized utilities—particularly artificially cheap power—are necessary to attract industry and commerce. Why this notion has gained so much currency I do not understand. It is true that large amounts of power are needed at low cost to make aluminum manufacturing pay. But for almost all other industries now being contemplated in the underdeveloped world it is how much is available, rather than how much is charged, which attracts industry.

A study prepared a few years ago showed that over a representative range of industries here in Mexico the cost of electric power averaged only 1.7% of total costs of production. The percentages ranged from a high of 3.8% in the paper industry to a low of 1% in textiles. In foundries and metal manufacturing operations it was 2%; in food processing, 1.6%; in woodworking industries, 2.4% and so on. If you compare power costs to the total value of production ,the average percentage drops to 1.2%. This study did not cover all the industries in Mexico : in the cement industry power costs are a more important share of the total. But still, these figures make it most difficult to argue that it is marginal differences in the price of power which encourage or discourage an industry from establishing in a given location.

On the other hand, the price of power can make all the difference in the world when it comes to providing an adequate power supply. A case in point is the huge Kariba Gorge project in Central Africa. This project is being built in two stages. The first involves damming the Zambesi River and installing half a million kilowatts of capacity; it will cost about $225 million. The second will bring capacity up to 1.2 million kilowatts at a further cost of about $100 million.

When the project was first presented to us, the Rhodesian authorities said they intended to sell the power cheap. The rates they suggested, in fact, would have resulted in an actual loss. This faced the Bank problem. Far from approving rates which would with a big return a loss in the first stage, we wanted rates which would return a substantial part of the money needed for the second stage, since we felt that without both stages the project could not justify the enormous investment involved.

After careful studies, the Bank recommended rate increases to yield about 35% more revenue from the first stage. Because this looked like a large increase the Bank undertook at its own expense a detailed survey of the power markets in the area to see how power users, present and potential, would be affected by such an increase. In no case, even among those industries which were very large power users or promised to be so in the future, was the increased cost more than a very small fraction of total costs. And everywhere we found willingness, if not eagerness, to pay a little more if that would mean a reliable and adequate power supply.

Today the first stage at Kariba is nearing completion. Instead of promising to be a monumental drain on the resources of the Rhodesian Federation, it promises to pay its way and to provide practically all the money needed to build the second stage. And the price of this promise can literally be figured

[*Continued on page* 24

Fabrication and Installation of Steel Penstocks at Bhakra Dam—I

By D. K. JAIN

During the British regime, under Indian Boiler Act, welding was not allowed on the pressure vessels, as the technique of welding was not developed to an extent that it could be considered safe for the human lives.

America has done much research in this field and the technique of welding has developed so much that a tensile strength of welding goes to normally 87,000 lbs. per sq. inch and sometimes more than the strength of the base metal. Special electrodes, flux, automatic welding machines, automatic cutting machines, generators of high ammerage for automatic welding machines, X-ray for industrial radiography, for the welding of the joints, high temperature upto 1100°F, stress relieving furnaces, low temperature controlled stress relieving for the field welds, and hydrostatic testing equipments—these are some of the developments of researches in this field by U. S. A. for the reliability of the welding joints.

In Bhakra Nangal Project, at Kotla and Ganguwal six penstocks of 19 feet 3 inches inside diameter each, of rivetted type, which were fabricated at the Govt. Central Workshops Amritsar for 34,000 kW. hydro-electric turbo-sets, were installed by the end of 1954.

After India got independence, boilers of the welded type with much higher steam pressures than before were imported into India for the sugar factories and modern thermal power stations. The Indian Boiler Act Rules regarding accepting of welded type ofboilers were modified. These welded type boilers are working very satisfactorily and no accident of bursting has come to notice. Pressure vessels of unfired type also come under the same category of fabrication as that of fired pressure vessels. Penstocks are fabricated with ASME specifications.

The low cost of fabrication and installation, and convenience of erection and transportation are the main factors in the reduction of the cost of welded type of pressure vessels which have replaced the rivetted type.

At Bhakra, ten penstocks of welded type, of 15 feet inside diameter with a maximum of $1\frac{7}{8}$" say 2" thick steel plates, of the fire box quality, nearly 740 feet length each, for the maximum head of 540 feet, for 1,500,000 h.p. each for hydraulic turbines, are being fabricated and installed.

Five out of ten have been practically fabricated and installed at site with the American technique and specifications. These are the first penstocks of such big capacity which have been installed in India.

Under the second Five Year Plan and also in future, in good many river valley projects, penstocks of hydro-electric generation will be required. The fabrication of the penstocks would have to be first taken in hand so that by the time the Dam foundations will be ready the fabricated penstocks would be ready for installation to avoid any delay in concreting the dam.

In order therefor that our engineers employed on such schemes may take advantage of the experience of the Bhakra Dam Project in this particular field, this article is prepared giving in brief, equipment of the machinery required, approximate cost of the equipment, details of working process and technique of fabrication and installation of unfired pressure vessels.

The author had valuable opportunity of erecting 3 penstocks of rivetted type at Kotla Power House, and of detailed inspection for two years of all the processes of fabrication of the installation in the Bhakra Dam.

Fabrication and Installation of Steel Penstocks of 15 feet dia. (inside) by Welding Process at Bhakra Dam each for 150,000 H. P. Hydraulic Turbine

This article has been divided into the following sections : 1. Material. 2. Equipment for lifting the material for different processes. 3. Equipment for cutting and bevelling. 4. Process for cold bending the plates and equipment. 5. Jig for assembling the two plates for making 10 feet section of 15 feet. dia. sections, and process. 6. Equipment for hand-welding 7. Equipment and process for automatic welding inside and outside for longitudinal and girth joints including assembling two sections of 10 feet each to form 20 feet section suitable for transportation to site. 8. Equipment for inspection of welding by X-ray or Gamma Ray Radio-graphy, and process. 9. Equipment and process for stress relieving furnace for a temp. of 1100°F. and also stress relieving by low temperature controlled method for field work. 10. Equipment and process for hydrostatic pressure tests. 11. Equipment and process for finishing, chipping, grinding etc. 12. Equipment and process for sand blasting. 13. Equipment and process for grouting the penstocks after concreting. 14 Equipment and process for painting of enamel coal tar paint to protect the corrosion inside the penstock plates. 15. Scroll Casing. 16. Bulkhead, stoney gates, Draft Tube Gates and Trash Racks etc. 16 Stainless steel piezometer plugs and system. 17. Expansion couplings. 18. General miscellaneous.

Material

First Box quality plates of steel were procured from Japan, England and West Germany and cost from

Rs. 700/- to Rs. 1400/- per ton according to market rates. Boiler Plate : MK 11316 JA 1495 Fire-Box quality.

Breaking stress : 26.8 tons per sq.inch. Elongation% 8 inch—29.00 Yield point 15.3 tons per sq inch.

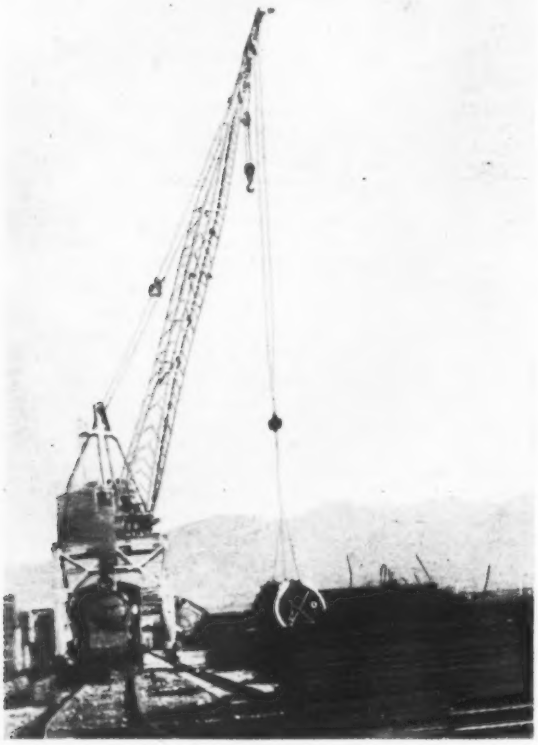
Size: 24 feet by 120 inch by $1\frac{5}{8}$ inch. Material inspected and certified by Messers : Colvillers Ltd. Methrewell for homogeniety and bending as satisfactory.

	Carbon	*Sil*	*Sulp.*	*Phos.*	*Mangnes.*
H 3924	.145	.05	.027	.020	.57
W. 4149	.155	.05	.022	.021	.62

supplied by M/s Mohatta Brothers (England) Bombay and Calcutta. and other firms.

Equipment for Lifting the Material

One Crane, "Colby" make, capacity 40 tons at boom 100 feet and 35 tons with 120 feet, driven by electricity 440 volts 3 phase 50 cycles A.C. with a total h. p. 200, working on rail track with maintenance



Colby Crane 40 tons. Boom 100 feet for lifting Penstock sections of 20 feet.

charges are Rs 28/- per hour. Secondhand costing about Rs 4 lakhs suitable for 50,000 working hours had been provided which is giving very satisfactory service without any trobule.

Equipement and Process for Cutting and Bevelling the Steel Plates

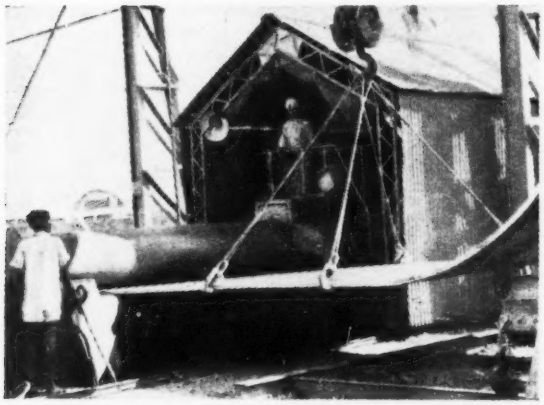
The plates which are 24 feet by 10 feet for 15 feet I. D. are placed on a levelled platform and cut to required size, after marking on the plates and inspected by the Inspection Department, by automatic gas cutting (flame cut) machine. Ends are levelled at 30° angle from one side or from both the sides, according to the thickness of the plates. Plates of Penstock sections one inch or more in thickness are double

Automatic Gas Cutting Machine for cutting plates and bevelling etc.

bevelled and ends of all sections less than one inch are cut single bevelled, with the bevel formed on the exterior surface of the joint. When the two plates meet together for joining, the "V" groove forms 60° angle. The automatic gas cutting machine which are used, are manufactured by M/s National Gas Cylinders Co. (USA), working with electric A. C. current 110 volt and transformer is used to work for 220 volts single-phase. These machines are giving very good results and are very light in weight, compared with the other machines such as that of the British Oxygen Co. Ltd. London. These machines cost about Rs. 800/- each in India. The bevelled edges are grinded to smooth the surface and the plate is ready for lifting to the bending machines.

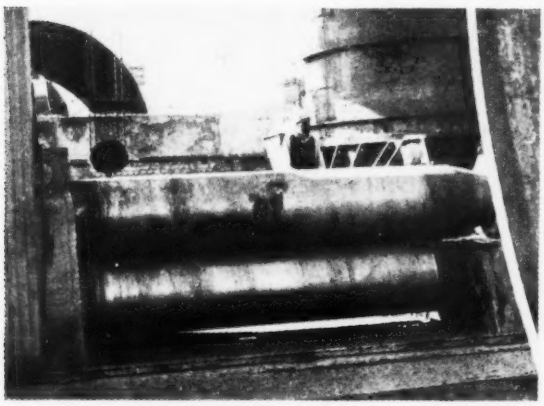
Process for Cold Bending and Equipment including Handling

When the plate is ready after being duly inspected for cutting and bevelling, the plate is lifted from the yard by the above mentioned Colby Crane and is taken over by another Crane manufactured by M/s Jessop and Co Ltd. Calcutta of 10 tons capacity in another yard, where the bending machine is installed. The above 10-ton crane is working with A.C. (400) volts on gantry rails which are installed about 20 feet high from the ground level and extended upto the structural workshops. The plate is put in the rolling machine and rolled cold to true circular section plate-gauge is used to see the curvature of the plate to its full length from one end to the other. A tolerance of one quarter inch viz $\frac{1}{4}$" plus or minus in a dia. I. D. of



Cold Bending Machine for plates upto 3 inches with 3 Rollers.

15 feet, according to specification, is allowed. The bending requires skill to bend the plates in such a way that the plate does not get undue pressure at a time and gives crack. In our works, no crack has been marked on any plate and the bending machine has given very satisfactory results. The rolling machine has been manufactured by M/s Chrmaeusler—Dormach (Switzerland) capacity 12 feet 2 inch length with three rollers

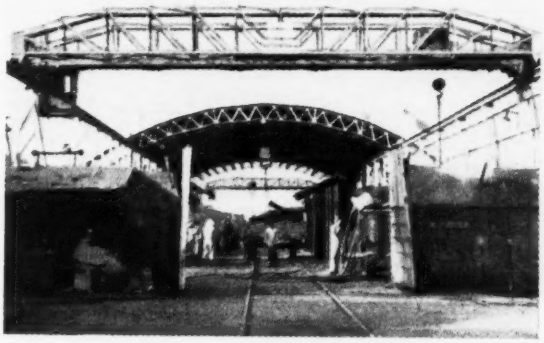


Cold Bending Machine's top and bottom Rollers each 30 tons.

dia. 28 inch, weight each roller 30 tons with reduction gear-arrangement, for working. The top and bottom rollers are kept in fixed positions for reqiured thickness. The side roller moves up and down with the pressure of 100 lbs. per sq. inch of compressed air, for giving the proper curvature to the plate. The end bearing plate cover of the top roller can be removed by air pressure arrangement, so that a curved rolled plate, after welding, for the pupose of true diameter at all places, may be inserted in the machine and the section may be rolled again, if found necessary after welding two plates to form 15 feet dia, section. This machine is worked with a main drive of 120 h.p. motor 3 phase 400 volts 50 cycle 948 r.p.m. with V. belts and one other 40 h.p. motor with reduction gear arrangement etc. M/s Garlic & Co. Ltd are the agents for India. The machine cost about Rs. 3,25,000 and can bend plates upto 3-inch thickness in cold condition and was giving very satisfactory results.

Alignment of Plates to from Penstock Section at Jig. of 10′ Length

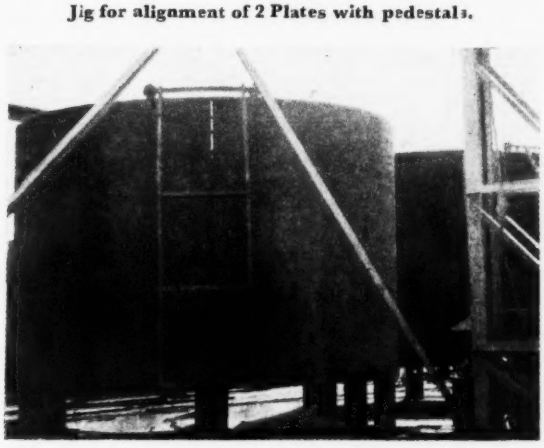
For making one 10 feet length piece section of 15 feet I. D. two plates of 10 feet by 24 feet are rolled as mentioned above. These two plates are put on the Jig



Overhead Crane 10 tons of M/s Jessops.

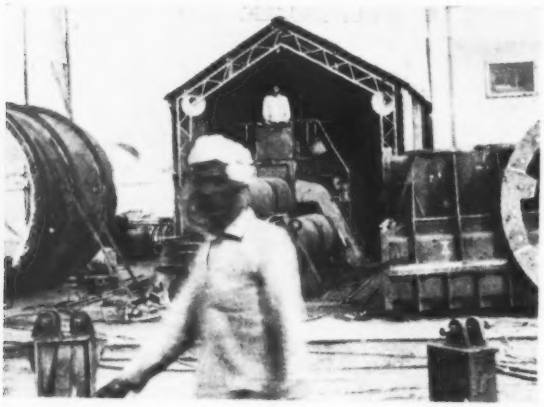
pedestals with the joint falling between double screws. by the 10-ton crane and aligned by using 'L' type lugs and line up lugs to straighten the edges and line up the piece. The gap between the two plates is put minimum 1/8″ max. 1/4″ for welding, according to the welding specifications. Exact diameter at all places on top, middle and bottom inside of the section is adjusted. with spiders. After it has been inspected and found true, the joints are tacked to keep the plates in position. One inch weld tacking after every six inch on the opposite side of the 'V' groove if single, is done.

Jig for alignment of 2 Plates with pedestals.



One stiffener ring of $\frac{1}{2}$" thick by 6" width of the firebox quality steel, which has been cut by the automatic gas cutting machine, to fit on the outer circumference is tacked and welded by hand on the outer surface of the penstock section in the middle, for keeping true curvature and two spiders, one on the top and one in the bottom of the section are fixed before tacking the joint.

For hand welding, welding-rods of fleet weld 5 of 5/32 inch dia. manufactured by M/s Lincoln Electric Co. (U. S. A) as per specification No. E. 6010 of the American Welding Society are only used which are giving very satisfactory results for vertical, horizontal, and all other positions of the welding and give tensile test of 80,000 lbs per sq. inch.



Pedestals showing double screws where plate joint falls.

Certified welders who had passed the tests of certified welders as per specification of welding of ASME, are engaged for the penstock welding. This test is being taken by the Inspection Directorate, which is very rgid.

Two spiders having six arms each, which are welded inside of the 10 feet section, to keep curvature true and for an adjustment and transmission from one place to the other, are only removed when the sections have been erected at site and concreted.

When both the plates of the 10′ section on alignment jig are tacked, stiffener ring is welded, and two spiders have been fixed, then one layer of weld of 1/8" thick called Rootpass is welded from the opposite side of the tacking. Tacking does not form part of the weld and is removed after automatic welding which is done on the next stage of the fabrication.

Equipment for Hand Welding

Fifteen sets of M/s Lincoln Electric Co. of U.S.A. are installed for hand welding giving 400 or 300 amps. on 40 volts D. C., rated for the continuous use, motor generator type, with 400 volts A.C. supply three phase, 50 cycle and cost about Rs. 4000/- each. M/s Martin Burn and Co. are agents of these in India. These sets are installed in the Fabrication Section of the penstocks and are giving very satisfactory results without any trouble and *work continuously*, in all the three shifts, when required.

Automatic Welding inside and outside, and Precautions before Automatic Welding is started in Penstock section

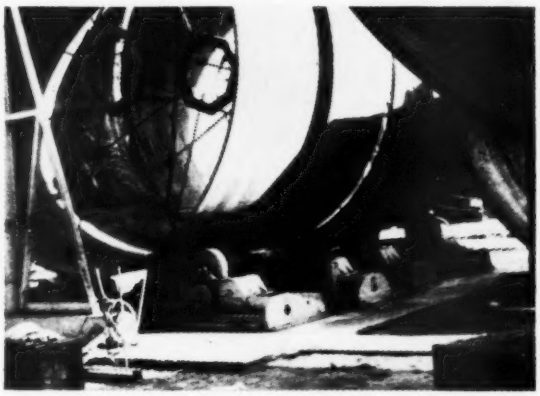
All surfaces to be welded should be clean and free from scale, rust, painting and other foreign matter. All welding should be done by the electric arc method by a process which will exclude the atmosphere from the molten metal and, where practicable, automatic machine should be used. The type of joint to be welded may be either a single or double "V" groove or "U" groove joints, shall be welded from both sides of the joint. The reverse side should be prepared by chipping, grinding or melting, so as to secure sound metal at the base of the weld metal first deposited before applying weld from the reverse side. All welding should be in accordance with the requirement of section W of 1951 edition of API-ASME Code. Weld metal should be deposited in successive layers and each layer should be cleaned of all slag and other deposits before applying the next layer. Tack weld, where used, to hold the section in line should be removed, so that it may not become a part of the permanent weld joints. Welded joints should be free from craters, depressions and other irregularities. After welding is completed all weld spatter should be removed. The re-inforcement layer in the inner side surface should not exceed more than $\frac{1}{8}$th inch above the surface of the plate. But in this project, the interior surface of the plate is chipped and kept flush in line with the surface of the plate, thereby increasing the efficiency by 5% more than if $\frac{1}{8}$ inch of re-inforcement of the welding is allowed. This also helps the water to flow smoothly without giving friction.

Only qualified welders for operation, who have not less than 6 months experience as welding operator on a similar job, should be employed. Before permitting to do any welding of production, each welder operator must furnish satisfactory evidence that he is qualified as mentioned in sec. IX of Standard qualifications for welding procedure and welding operation of the ASME boiler construction code. The test plate from which the specimens are prepared for the qualification test of welding operators should be of such a dimension that all of the specimens for the required tests can be obtaind without discard at each end of each test plate of not less than 2 inches. The test plate should be made of the same material as used in the penstocks. The technique of welding the test plates, including the rate and position of welding and the welding rods used for welding should be the same as used in the fabrication of the penstocks.

Test plates representing a longitudinal welded seams, should be attached with the shell plates being welded so that the edges to be welded are continuous of the penstock. These test plates are tested in the laboratory for the tensile strength etc. which should be between 70,000 and 85,000 lbs per square inch for the test of production welding, as required by the API-ASME. Code para U. 68 Section viii of ASME Boiler construction Code.

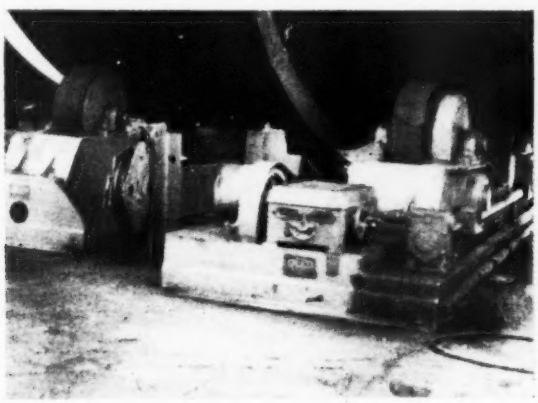
Automatic Welding Equipment and Procedure for inside and outside of Longitudinal and Girth joints

When the section of 10 feet length and 15 feet I.D. has been completed of the size, as mentioned previously and is ready, the section is removed from the Jig by the 10-ton crane and is taken over by the Colby 40 tons crane and put on the automatic roll on which two sections of 10 feet length are put to make a section of 20 feet length.



Welding Automatic, Roll and its rotating arrangement for 20 feet section.

The two pieces are aligned by putting L type and line up lugs all round the girth joint, with deviation plus-minus on either side of the place of 1/16 of an inch. Particular care is taken in matching the edges of the adjoining plates and courses to ensure that at all but welded longitudinal joint and girth joints, the inner surface of the plates are in continuity within maximum off-set at any point of 1/16″.



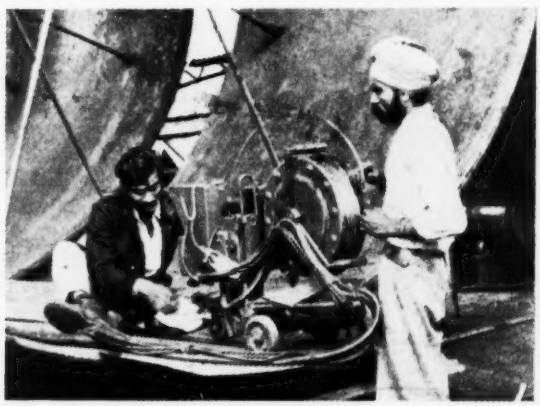
Power driven rotating gear for automatic welding roll.

The procedure for the girth joint to make it 20 feet section is the same as that of longitudinal joint for preparing for automatic welding, which was described previously when the two plates were on the alignment jig to make it 10 feet section, viz. taking after alignment, putting rootpass of $\frac{1}{8}$″ thick of one layer by hand welding, so that when automatic welding is done, owing to the deep penetration of the electrodes the molten metal of the electrode may not fall down from the bottom of the joint.

Equipment for Automatic Welding inside of the Penstock section of 20 feet length by 15 I.dia

Jig frame: This frame of Messers Reves & Co. consists of 8 roller wheels which are fixed on four frames, on which 2 section of 10 feet length, as mentioned above, can be assembled, having arrangement of rotation with 2 h.p. motor with reduction gear, so that the 20 feet piece can be rotated at slow speed for the automatic welding of girth joint. Each wheel roller is of 2 feet dia by 6″ width with solid rubber tyre and is fixed on the frame with grease lubrication.

Automatic Welding Machine: This machine is made by M/s Lincoln Electric Co. of U.S.A. meant for welding inside of the tube for longitudinal as well as for the girth joints. The machine is mounted on the trolley having 3 wheels and arrangement for the travel of the trolley by one electric motor of 1/4 h.p. volts 110-115 D.C. r.p.m. 1100 with reduction gear with control switch. The speed of the travel is regulated from the switch-board which has been provided separately for the operation of the trolley travel for the electrode



Inside automatic Welding Machine.

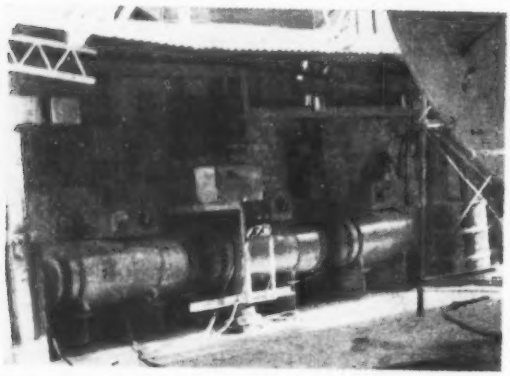
from the electrode drum to the welding point in the joint. One 1/12″ h.p. motor 110-115 volts D.C. is provided for the travel of the Electrode with reduction gear. Both the motors are of M/s Robinson & Co and special electrodes of M/s Lincoln Electric Co. are used for automatic welding which are of two sizes. One of 5/32″ dia, and other is 7/32″ Dia. Flux used for automatic welding is also of special quality supplied by M/s Lincoln Electric Co. for which M/s Industrial Gass Ltd. are the agents in India. For automatic welding machines M/s Martin Burn & Co. Ltd. are the agents.

Switch Board of Automatic Welding Machine for Inside: The switch board shows 2 scales. 3000 amps and 1500 amps range to o, from one Ammeter

Switch-board for automatic welding machine.

D. C., Volt Meter shows from 0 to 50 volts D. C. The board has got equipment for speed controls and regulators for Amps and Volts for the automatic welding machine.

Motor Generator for Automatic Welding Machine for Inside: Two welding sets of S.A.E. 900 amps each. bolts 40 D.C. of M/s Lincoln Electric Co. (U. S. A.) motor 400 volts A.C. three phase 50 cycles are put in parallel to give 1800 Amps D.C. with control gear. In one of the sets the exciter is of 110-115 volts which



Generators for inside, automatic Welding Machine capacity 1800 amps. and one Generator of 750 amps for outside automatic welding machine.

also gives current for two D.C. motors of the 110 volts used in the automatic welding machine for the travel of the trolley and electrode. The exciter of the 2nd machine also gives 35 volts D.C. for operating relays. The approximate cost of the above equipment of automatic welding machine, switch-board and two generators is Rs. 25,000/-

Welding Procedure for longitudinal Joints inside of the Penstock

1. First put starting pads on both ends of the plates which also serve as testing plate for laboratory test when 20 feet section has been aligned, tacked and one layer of welding 'Rootpass' has been put, and is ready for automatic welding on the automatic welding roll as mentioned above, one of the longitudinal joints of 10 feet section is put straight in horizontal position and the automatic welding machine is put on the longitudinal joint in such a way that the electrode of the machine goes straight in the bottom of the joint, which is in the shape of 'V' groove, where Rootpass has been put.

2. Then see that the machine travels in straight line over the joint.

3. Adjust and see that the electrode goes down correctly in the joint.

4. Adjust the welding set generators on 'Heavy Electrode' and amps to 700 each on both the machines which are running in parallel.

5. *For the first layer of the welding*, use welding rod of automatic welding machine of 532 inch dia. and roll it on the electrode rolling drum.

6. Adjust on switch board by the Regulator amps 700 to 750 by putting the regulator on No. 6.6 Adjust volts 32 by putting the Regulator on No. 6.4.

7. Adjust speed of the travel on No. 9.5.

8. Start by pushing the bottom of the machine 'To set Arc' and put the switch on automatic mark.

9. When arc starts, put the flux release so that the flux falls on the welding.

10. Go on welding in straight line. Metal will be coming in more than $\frac{1}{2}''$ thickness in the 'V' groove of the joint.

Second layer of welding: 1. Adjust at switch board at amps 800 and volts 34.5 by Regulators and speed at No. 9.5

2. Electrode should be used of 7/32″ size.

3. Start as before and follow as per first layer procedure as mentioned above.

1. *Third layer of Welding:* Adjust at Switch board at amps 1000 to 1200, volts 38 to 40 and speed on No. 10.5 to 12 and proceed as per second layer. Use electrode 7/32 inch size. as in the second layer. The welding should come upto 1/8″ above the plate surface. This procedure is meant for a plate of 1-7/8″ thick having 'V' groove bevelling on both sides of the plates.

Vacuum-Cleaner for Flux.

The machine is manufactured by Invincible Vacuum Cleaner Manufacturing Co. of U. S. A. It consists of motor A.C. 440 volts of 1.5 h.p. and driving a fan, with 'V' Belt. r. p. m. 2900, and costs about Rs. 4000/-. This machine by vacuum sucks up the excess of flux powder from the welding joint which is screened in

the machine and again used as flux in the automatic welding machine. This saves sufficient amount of flux which falls on the welding molten metal from the automatic welding machine.

Automatic welding for outside and Equipment

Equipment Required

One generating set supplied and manufactured by M/s Lincoln Electric Co. (U. S. A.) giving 750 amps. on 40 volts D. C. (S. A. 750) and driven by A. C. 400 volts motor. This also gives current to two motors of 110 volts to Automatic Welding Machines for the travels of the electrode and machine, from its exciter.

Second Generating set gives 35 volts D.C. for the relay's operation and is driven by 400 volts 1.7 Amps 3 Phase 50 cycle 1500 r.p.m. motor.

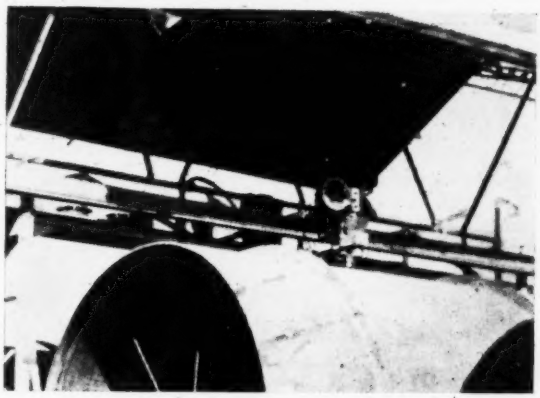
Jig plate-farm for outside Automatic Welding Machine A special jig plate-farm, is made for mounting this Automatic Welding Machine for outside welding.

Jig for outside welding automatic machine.

On the top a rectangular frame 8″ × 6″ about 20 feet in length with machine surface, is fined and supported on both ends by columns having arrangement for lowering and raising the above steel plate on which the machine is mounted and travels, so that machine may be set and adjusted to enable the welding electrode to reach on the joint for welding. On the top of the jig, corrugated shed is fixed to protect from rain etc., and sufficient electric bulbs are put. The complete Jig frame is mounted on wheels and can be moved on track rails for a distance of about 20 feet for different operations of the penstock welding.

For the logitudinal automatic welding, the Machine travels on the above mentioned rectangular frame by an electric motor D.C. 1/6 H.P. 115 Volts, 3700 r.p.m with a reduction gear and current is supplied by the above mentioned generator's (S.A. 750) exciter.

Automatic Welding Machine for outside : The machine is manufactured by M/s Lincoln Electric Machine Co., (U. S. A.) and the switch-board is mounted on the machine itself.



Outside automatic welding machine for outside with switch board.

The machine has got two D.C. motors, one of 1/12″ H.P. 110 volts for the travel of the electrode, and second of 1/6th H. P. 110 Volts D.C. for the travel of the machine on rectangular frame on which the machine is mounted. The switch board has got one ammeter with a range from 0-1500 and 0-3000 amps. One volts meter for D.C. 0-50 volts, regulators for the speed control of both the above travels and regulators for amps and volts.

The machine equipment consisting of the automatic machine, both generators costs about Rs. 25,000/- with switch gear etc.

Procedure for outside welding

As mentioned for the automatic welding for inside welding previously, after the two sections are assembled on the automatic roll where the 20-feet section can be rolled by the rotating arrangement by reduction gear, the automatic machine is brought on the joint and adjusted, so that welding rod goes straight in the "V" groove of outside plate. On both ends of the section test plates are welded so that the edges to be welded are continnous of the corresponding edges of the longitudinal seams of the penstock.

Automatic Welding for outside

Operation for Longitudinal : (a) For longitudinal seams, the machine travels on the jig. Both the generators are started and set for maximum load. Inspect that the machine travels in straight line over the longitudinal seams. See that the electrode of the machine goes in the 'V' groove straight in the bottom.

(*b*) For the first layer use 5/32 electrode used for automatic welding.

(*c*) Adjust the amps on switch board for 500-550 amps.

(*d*) Adjust the speed on No. 9.5

(*e*) Start by pushing the button 'To set Arc' and put the switch on automatic mark.

(*f*) When the are starts put the flux release so that the flux should fallon the welding of the molten metal.

(*g*) Go on welding in the straight line and metal will be melting about 3/8″ thick.

(*h*) Stop when the machine reaches on the other end.

Second layer: Clean the joint, remove any slag etc. as mentioned in the instruction and precautions before welding and set the machine from the opposite end for second layer.

1. Use electrode of 7/32″ size and adjust the machine as it was done in the first layer.

2. Adjust the amps on 600-650 and volts to 34.5.

3. Weld as it was done for the first layer.

Third layer : Remove the flux, clean the joint, and set the machine for 750-800amps using 7/32″ size electrode and adjust the volts. 38 to 40 V. The machine can take 25% overload and can give a 1000 amps.

See that the metal has come up by 1/8″ higher than the surface of the plate. If not, put a layer of weld for re-inforcement as mentioned before. This procedure is meant for a plate of 1-7/8″ thick, having "V" groove on both side of the plate.

Welding on Girth joint : In the girth joint, the machine is fixed so that electrode goes straight in the groove of the joint. The penstock section is rotated by means of rotating arrangement in the Automatic Roll by reduction gear and welding is done similar to the welding of longitudinal joint welding as mentioned above for adjusting, the amps and volts for first second and third layers.

Welding of Girth joint inside the penstock : The inside welding machine is put in the inside of the penstock similar to that done for the longitudinal welding seams and the procedure is also the same in the case of girth joint. The machine is put on the bottom of the section in the direction of the girth joint and care is taken that the direction of travel of the machine should be opposite than that of the rotation of penstock section. That is if machine is moving in clock-wise direction then the section of the penstock should rotate anti-clockwise, so that the machine always remains in the bottom of the penstock in level and the electrode goes straight vertically in the 'V' groove of the girth seam.

Test Plates

After the welding of inside and outside is completed satisfactorily and passed by the Inspector after 100%X-Ray test, the Test plates, which were welded on both sides of the plate, are removed and are sent for laboratory test, for inspection of the Inspector for the tensile strength of the joints.

Acknowledgement

My profound thanks are due to Shri R. S. Gill, Director of Inspection and Control, Bhakra Dam for his mature advice and permission to publish the illustrated article. I also owe a deep gratitude to Shri. J. S. Clair, Superintending Engineer, Shri. R. L. Khanna, I. S. E. Chief Engineer, and Shri. M. R. Chopra I. S. E. General Manager, Bhakra Dam for the opportunity afforded to me to study the various processes in detail.

(*To be Continued*)

EARTHMOVING OPERATIONS IN INDIA

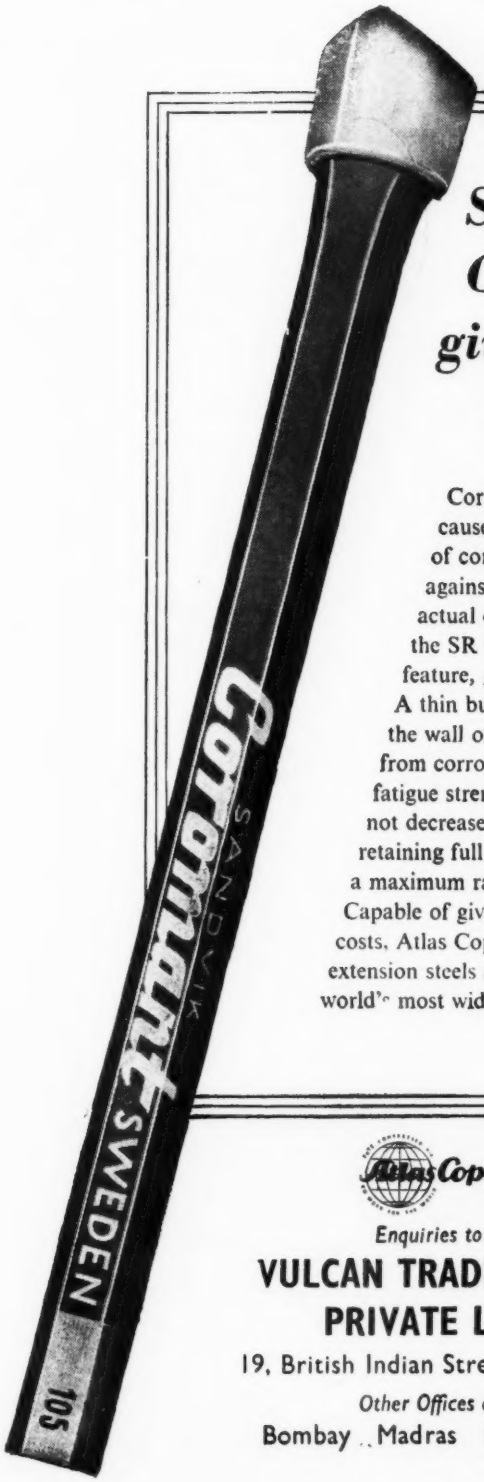
Since Independence, India has undertaken many new projects, involving earthmoving work of colossal magnitude, for conservation and control of water resources of the country.

Of these, the major multi-purpose river valley projects, such as the D.V.C., Hirakud, Bhakra-Nangal and Tungabhadra, required, in varying degrees, large-scale earthmoving operations. For instance, at Hirakud, earthwork of 25 million cubic yards—its excavation, transportation and consolidation—was completed by mechanical methods.

At the more recent projects as well—Kosi, Chambal, Nagarjunasagar and Rajasthan Canal, to mention a few—immense earthwork is being undertaken at present.

In addition, rail, road and highway systems, open-cast mining and similar activities require considerable earthmoving work.

Earthmoving machines, now available in India, and valued at Rs. 510 millions, include, roughly speaking, about 100 draglines, shovels, etc., for excavation, 500 dumpers, and a similar number of scrapers. There are also 800 tractors and 100 graders in the country. To maintain and keep this costly equipment in trim, there is a chain of workshops throughout the country.



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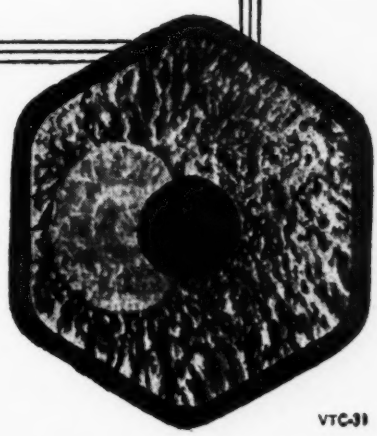

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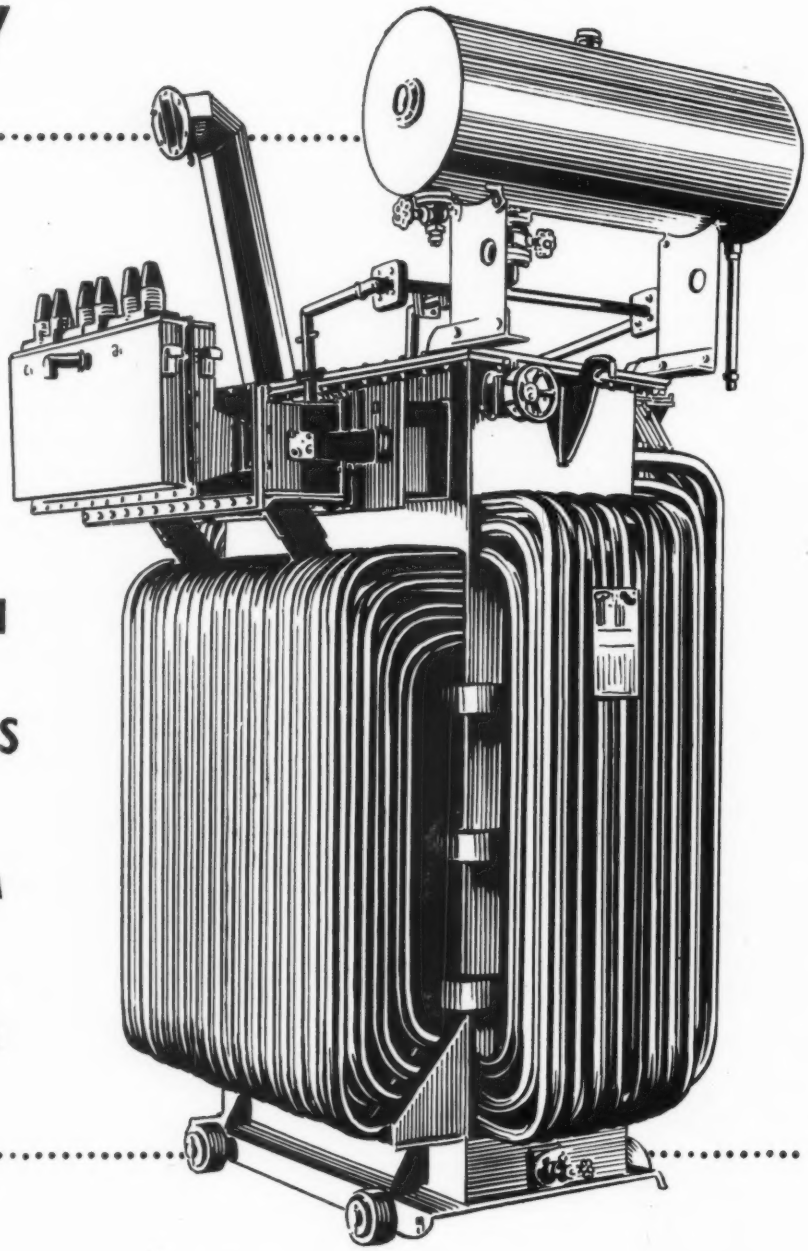

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Transformer Surge Protection : Some remarks on positioning of arcing horns

By S. SZAFRANSKI

According to practice prevailing in certain systems the Arcing Horns provided by the makers for surge protection on transformer bushings are removed from them and placed on the nearest pole structure adjoining the transformer substation. This measure, it is argued, is necessary to avoid the outages caused by birds and various parts bridging the horn gap and thus causing the earth faults on transformer terminals. Without passing any comments on efficiency of such steps for the purpose as stated, attention should be drawn to the dangers involved in the event of an overvoltage surge appearing on the line.

To illustrate the problem a 3000 kVA, 33/11 kV delta/star connected transformer will be considered. Further, a surge on phase A of the overhead line will be assumed. Before the transformer terminal is reached the crest of the travelling wave will be chopped by the arcing horns, mounted some distance away from the transformer, to a value usually corresponding to 80% of the impulse strength of transformer windings. In the present example this would be 80% of 210 kV, say about 168 kV.

On entering the windings the amplitude of the surge would undergo a series of oscillations, governed by the winding parameters, before arriving at a final linear voltage distribution. Mathematical analysis, as well as the practical examination of surge phenomena in case of a rectangular wave is in a broad agreement with the actual tests on 1/50 surges. It is found that for windings with free unearthed ends, which is the case under review, the initial voltage distribution follows the function

$$Us\,(x) = U_s \frac{\cosh \sqrt{C_e/C_s}\,(Z - \frac{X}{l})}{\cosh \sqrt{C_e/C_s}}$$

Where :

U_s ....applieds urge crest volts
$U_{s(x)}$..Voltage to earth at the point x of winding
l....length of winding
C_e ....capacitance to earth of winding
C_s ....series capacitance of winding

Under most unfavourable conditions the voltage distribution along the windings during oscillatory period may assume the shape reversed of the curve representing the intial voltage distribution along the windings, as shown on fig. 1. This means that the voltage at the end of the phase winding would be doubled and in our example it would reach a value of 338 kV, which is 160% of the specified impulse withstand voltage of the windings. Should the arcing horns have not been removed from the terminals B and C the surge would normally be reduced in this very instant to its initial value of 160 kV by the operation of the corresponding horn gaps connected to the ends of phase windings. As it is, since the horns have been removed, the surge will travel further and enter simultaneously the winding of phase B and the overhead line connected to the terminals (see fig.2) and it will impose on the windings a certain definite potential gradient before the arcing horns placed on the pole structure will again operate.

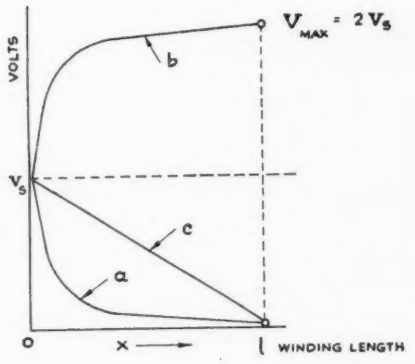

FIG-1

VOLTAGE DISTRIBUTION ALONG PHASE WINDING OF A DELTA CONNECTED TRANSFORMER WITH CYLINDRICAL WINDING AND RATIO $\sqrt{C_e/C_s} = 10$

a - INITIAL DISTRIBUTION
b - MAXIMUM OSCILLATION
C - FINAL DISTRIBUTION

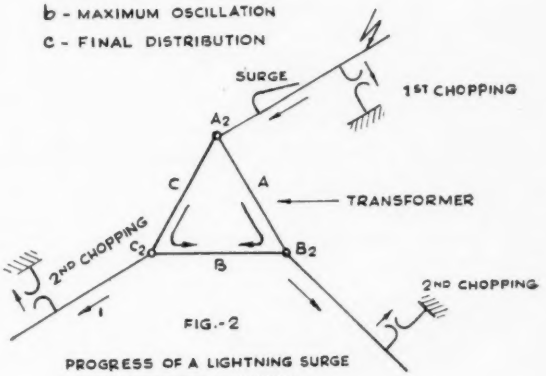

FIG.-2

PROGRESS OF A LIGHTNING SURGE IN TRANSFORMER WINDING

In considering the above course of events it may be argued that the time to travel from the terminals B

and C to the corresponding arcing horns would be negligible, because the intervening distance is rather short and consequently the horn gap in the vicinity of the transformer will act in this very instant chopping the surge to 168 kV before the electric stresses applied to the winding can do any damage to the insulation. In the actual practice the distance between the transformer bushings and the place of location of arcing horns on the substation structure may be about 20 to 40 ft along the conductor, possibly even more for higher voltages due to clearance considerations. Taking in the present example this distance as 25 ft the time of travel of the surge from the bushing to the horn gap will be in the region of :

$$t = d/v = 25/100 = 2.5 \times 10^{-2} \text{ microsecond}$$

(The velocity of the surge is about 1000 ft/microsecond on open transmission line)

At the same time the surge will continue its progress along the windings into the coils of the phase B.When the flash-over of the externally placed horns will eventually take place, that is in 2.5×10^{-2} microseconds, the surge will cover a distance in the windings :

$$d = t \times v = 2.5 \times 10^{-2} \times 530 = 13.3 \text{ ft.}$$

Remark :

The surge velocity along the winding conductor is determined by the fundamental equation:

$$V' : = \frac{C}{\sqrt{kp}} \text{ ft/microsecond}$$

where :—

c-denotes velocity of light, k—permittivity of the circuit, p—permeability of the circuit. For oil immersed transformers k equals 3.5 and p equals 1.0, gives this for v′ a value of 530 ft/microsecond.

Now, in a 3000 kVA transformer the mean length of a turn of HV coil may be about 3.5 ft, it follows that the surge in the interval of 2.5×10^{-2} microseconds would penetrate within 13.3 / 3.5=4 turns and would reach a value of $338/530 \times 13.3 = 8$ kV on the last turn. Thus between 4th and 5th turn will arise a difference of potential of 8 kV, far in excess of the working stress of about 25 volts per turn (in case of a 3000 kVA unit). This is 8000/25 or 320 times above normal and is, of course, undesirable. A well insulated and properly maintained transformer, in dry condition would be expected to withstand the momentary stress of this magnitude, but it may not be so in case of older transformers where the insulation has lost its original properties.

It is clear from the foregoing that the magnitude of the transient inturturn stress will grow with the distance at which the protective arcing gap is placed away from transformer, because with the increase of time delay to chopping the surge will be allowed to build up and travel within larger portion of the winding. In the extreme case of nonprovision of any protective device in the vicinity of transformer the ultimate effect will be a flash-over at the bushing terminalsor suspension insulators, or—which is more likely—the internal breakdown of the major insulation of transformer windings, probably followed by a discharge at power frequency.

To sum up, the practice of removal of arcing horns from bushing terminals of transformers is dangerous and should not be recommended, as it may easily lead to winding failure under a lightning surge. This fact in the light of reasons discussed above is generally appreciated now-a-days and the present trend is towards "integrated" protection achieved by placing of lightning arrestors directly on the transformer tank, or providing an internally mounted surge divertor. In the absence of such devices, perhaps not justified for smaller transformers, the time-honoured arching horns are perhaps the simplest and least expensive protective measure.

The outages due to accidental bridging of the gap may be minimised by adopting "duplex" construction. In many cases the closing of the gap by living organism may be only of a short duration, because a small animal or an insect will be instantly killed and will drop out before sustained arc will produce earth fault on the line. In exceptional cases such outages may be frequent in some areas. It would be of interest to give a further study to the problem and collect more facts—the writer would be greatful to receive from the field brief accounts of the actual instances of outages caused by birds, lizzards, rats etc. etc.

STEEL CONDUITS FOR ELECTRICAL WIRING

An Indian Standard Specification for Steel Conduits for Electrical Wiring [Doc: ETDC 7 (5)], specifying the material, dimensions and other general requirements, has been drafted by the Indian Standards Institution for eliciting comments from the interested manufacturers, consumers, testing laboratories etc. before the 9 December 1959.

Though conduits and fittings are very closely related with respeect to dimensions, screw threads etc, since these two items are manufactured by different producers, it was felt desirable to have two separate specifications—one on steel conduits and another on conduit fittings and accessories.

In persuance of Government of India's decision to adopt metric system the dimensions in the draft standards have been given in the metre system with the corresponding ISO sizes in brackets, since the latter represent the practice followed by the trade at present. The dimensions are based on ISO recommendations.

Copies of the draft are available free on request, from the office of the Indian Standards Institution 'Manak Bhavan' 9 Mathura Road, New Delhi, and from its branch offices at Bombay, Calcutta and Madras.

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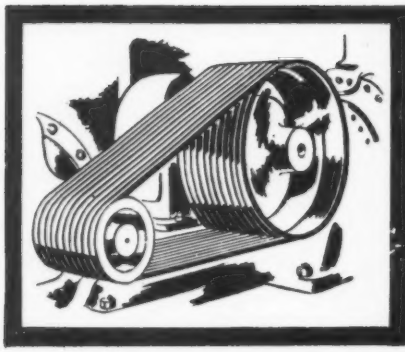

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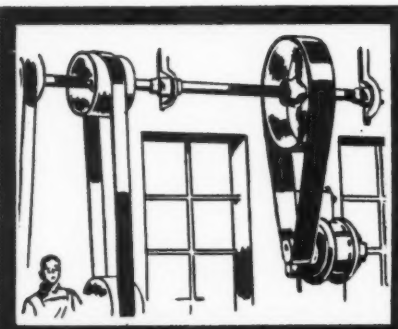

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Criteria for Fixation of Water Rates and Selection of Irrigation Projects

By C. S. PARTHASARATHY

The publication with the above name by the National Council of Applied Economic Research gives the results of the studies undertaken by the Council at the instance of the Central Water and Power Commission on the following aspects and attempts to suggest certain broad principles for selection of irrigation projects and for fixation of water rates:

(*i*) Investment criteria: existing system.
(*ii*) Consequences of existing investment criteria.
(*iii*) Method of allocating resources in a planned economy
(*iv*) Benefits of irrigation.
(*v*) Determination of water rates—method of application etc.

Part A of the publication, consisting of Chapters I to VI, deals with Investment Criteria and Part B consisting of Chapters VII to IX with fixation of water rates. The summary and conclusions are given in chapter X of the report. The paragraphs that follow bring out briefly the salient features contained in the report and contain comments thereon wherever considered necessary.

The results aimed at and conclusions drawn are based on a case study of the Sarda Canal area in Uttar Pradesh. The report recognises the limitations on which the results of the study have been derived and the conclusions drawn therefrom. It is also necessary to point out that the Sarda Canal cannot be regarded as a typical case and the findings and conclusions should be considered as illustrative rather than of general value or applicability. At the outset, therefore, it would be well to recognise that it will not be appropriate to extend to the whole country the findings and conclusions derived from this, a single study of the Sarda Canal system. However, in favour of the report, it should be accepted that it is written in an exceedingly interesting style and for most part of the reader's journey through the book, his attention is sustained and gripping.

The report emphasises the need for modification of the existing practice and procedures adopted for selecting irrigation projects on the basis of estimates showing the total amount of revenue anticipated by Government by way of direct receipts or the number of acres of land which can be irrigated by them and strongly recommends that a full economic appraisal of every irrigation project should be made before critical decisions about its implementation are reached. For this purpose, the evaluation should be in terms of the probable contribution of the benefits from the project to the national income, in terms of social benefits and social costs. Regarding water rates, the study leads to the conclusion that the prevailing system of fixation of water rates is not based on any rational or scientific principles. According to the report, the only sound guiding principle which can serve as a basis, is a levy based on a certain percentage of the net benefit accruing to the cultivator through increased farm products. A fleeting reference is also made to the delay in the utilisation of irrigation potential and to the management of the distribution of water. To achieve the object in view, constitution of Water Rates Board is recommended.

Investment Criteria

Chapter II deals with the existing system of investment criteria. In the past, the irrigation policy was that the financial results of the irrigation works were the best test of utility. The report (p.10) makes mention of the different rates of financial return required for a project to be considered productive. Since 1954, a rate of 4.5% return has continued to stay. Speaking of the existing criteria, it is stated in page 11 of the report that "productive works predominate to such an extent that, taking India as a whole, revenue from irrigation works exceeds the cost of maintenance and interest chagres by a useful margin." This was generally the position in undivided India i.e. before 1947, but the position has considerably changed since then. Here it is pointed out that according to the Report of the Second Finance Commission (1957), the revenue position in regard to irrigation works has deteriorated considerably. It is possible that a thorough analysis of the irrigation projects may show that broadly speaking the revenue from irrigation works undertaken during the First and Second Plans may not go to meet even the maintenance and interest charges thereon. According to the report under discussion, there has been little modification in regard to the investment criteria and even if there were little changes, they have been made on an *ad hoc* basis. This may be true to some extent. The recommendation for replacement of the existing financial productivity test by an economic productivity test appears to be a sound one.

Touching upon the "Government's attitude towards change of investment criteria" (p.13), reference is made to the policy of the Planning Commission in regard to inclusion of irrigation projects in the Plan and the report observes that decisions in regard to questions of broad irrigation policy are arrived at on an *ad hoc* basis. In the Plan reports, there may be no specific mention of social benefits and social costs in the evaluation and appraisal of irrigation projects, but that does not mean the broader aspects have not been kept in view. The choice may not be one between development of re-

sources of different regions through irrigation or through other means as if these were necessary alternatives. Irrigation programmes, it would appear, have to be undertaken in any event. The main question that can be considered usefully is the kind of balance that may be struck during each phase of development between irrigation and other fields of developments. It is further alleged that "nor has the Commision suggested any change in he existing machinery for the administration of water systems and distribution of water. " These and other matters have been and are much on the mind of the Planning Commission although it may not be possible to deal with all aspects in detail in the report on the Plans, due to various reasons such as limitation of space etc. Page 14 contains quotation from Deputy Chairman's (Planning Commission) address to the Central Board of Irrigation and Power in 1953, regarding "productive" and "protective" irrigation schemes. It is not clear from the concluding sentence of chapter II as to what is the 'much harm' that may be done to the cause of economic development of India", in regard to the necessary changes for a broader outlook. There seems to be no justified cause for this tone of alarm.

The history of the Sarda Canal in U.P. is the theme of Chapter III. It attempts to bring out evidence of the working of the restrictive investment criteria followed in regard to the actual investment, namely, the formulation of the project, the timing of investment and the management of the supply of water. Many of the facts and figures quoted in this chapter, it would appear, are for the Government of U.P. to comment upon, including the conclusions drawn therefrom. Based on certain statistics, the report observes that there has been no significant increase in the net area sown in the districts covered by the project nor has there been any development by way of double cropping. The areas cultivated during the kharif and rabi seasons show no notable change. Thus, on the whole, the area under irrigation has not increased in any significant manner despite the introduction of cannal irrigation. In fact, according to the report under discussion the opening of the Sarda canal has led to displacement of both bullock and manual labour. This, alongwith other factors, has adversely affected the established farming in the area in the initial period of operation of the canal. The report lists out the questions (p. 21) that should have been sought to be answered if a proper economic appraisal of the project had been undertaken before its excution. It would appear that the study of the canal has brought out the need for acceptance of the criteria of social benefit and social costs or contribution to the national income for investment. According to the report "it is possible that a good deal of concealed political inffence is exercised in the selection of the projects, but exactly how much it is difficult to say. Nevertheless, the risk certainly exists." "The report proceeds to say that "what is still more disturbing is the suitable way in which the consideration of the financial aspect alone in the formulation of a scheme influences attitudes in various ways" and a narrower view "gives greater consideration to current circumstances than to the potentialities of development on the long-run".

It is alleged that the whole plan for the Sarda Canal project was not at all examined in the light of various alternative proposals and no reasons were given for disregarding the recommendations of the Irrigation Commission (1901-1903) in regard to this project. One of the defects pointed out in the report is that the water has not been received by the cultivators in the required quantity and at the proper time. The guls are often not kept clean and there is much wastage of water with the result that the cultivators' water requirements are not fully met although sufficient supply may reach the kulabas (pipes). As mentioned earlier, it is for U.P. Government to look into these points.

The consequences of existing investment criteria form the subject matter of chapter IV, according to which the financial productivity test existing at present leads to several adverse consequences in the formulation of a scheme, in the timing of investment and in the management of the distribution of water. Two main reasons are advanced for non-acceptance of the present financial productivity test, namely, (i) the present yard-stick is out-dated in the prevailing social and economic policy enunciated under the plan; (ii) it does not take into account the advances in the field of technology and economic analysis: and (iii) therefore, it retards the economic development of a country. Touching on the changes required under a planned economy as distinct from a market economy, the report points out that it is necessary to introduce several structural changes in the economy by way of adequate provision of social and economic over-heads like irrigation, transport power etc. It is recommended that the appropriate criteria for investment in irrigation should take into account all direct and indirect effects of irrigation. It endorses the view of the Taxation Enquiry Commission (1953-1954) that the question of investment in irrigation should be examined from the point of view of the totality of economic welfare. The criteria should ensure adequacy of social and economic overheads, taking into account social benefits and social costs of such investment. It is further observed (p. 28) that "decisions are now taken on an *ad hoc* basis and hence there remains a difficulty in project evaluation and in determining priorities of projects *inter se*".

The advantages of irrigation are briefly described on page 29 of the report. It is emphasized that the investment criteria for irrigation should take into account the fact of the increase in national income the built-in stability of the economy and the progressiveness imparted to the economy by irrigation projects. According to the report, the "constitutional responsibility of the States for irrigation acts as an obstacle to development and projects are not evaluated so much in terms of their potential contribution to national income as in terms of their potential contribution to the incomes of the States." It is considered necessary to devise a new constitutional arrangement between States and the Centre in regard to investment in irrigation, which will over-come this obstacle. A case has thus been made out in the report for modifying the present criteria. A new yard-stick for investment in irrigation recom-

mended in the report should satisfy the following conditions:

(*i*) It should be broad enough to be used for various purposes;

(*ii*) It should be simple and easily understood ;

(*iii*) It should be capable of expression in quantitative terms; and

(*iv*) It should permit consideration of other factors, accepted in the plan, in the assignment of priority.

Chaper V dwells upon the methods of allocating resources in a planned economy. It deals with capital/output ratio, input/output ratio benefit/cost ratio, etc. The basic similarity in all these three techniques of evaluating the economic worth of an irrigation project is briefly discussed. Among the benefits, both direct and indirect, some are tangible and can be expressed in monetary terms while some are intangible and cannot be so expressed.

The investment criteria recommended (p. 36) includes estimates of anticipated social benefit and social cost which should be accepted as guides to resources allocation for irrigation projects. The rule to be followed, including fixation of *inter se* priority among irrigation projects, should be this; namely, the marginal social benefit of technically possible increment of investment must be equal to the marginal social cost and the ratio between the marginal social benefit and the marginal social cost must be the same for all investments. This is perhaps a theoretical ideal. In practice, the application of this principle may be beset with difficulties such as the determination of the life of a project, identification and measurement of social benefits and costs. However, this appears to be a useful tool for economic appraisal of a project. The difficulties are briefly discussed in page 37-38 of the report and may be briefly put down as follows:

(*i*) Estimating the project life ;

(*ii*) Estimating the prices at which goods and services are to be valued; and

(*iii*) Estimating the risk and rate of return on the basis of which the benefits and costs may be expressed in a comparable form i.e. in terms of annual benefits and annual costs.

The report makes reference (p.39) to various priority criteria laid down by the Planning Commission in the Plan for purposes of investment in irrigation. A brief reference is also made to the practice in other countries including U.S.A. Page 41 discusses the contribution of income from irrigation to the increase in national income. By this, it may be possible to find out whether adequate funds have been provided for irrigation as compared with those for other sectors of the total Plan. It is also necessary to keep in mind the long-term achievement of benefits from irrigation projects and any current programme of irrigation should be looked upon as part of the perspective plan for the next 15-20 years. Similarly, in regard to allocation of funds to major, medium and minor irrigation schemes, it can be made on the basis of the measurement of their contribution in terms of net profits of the newly added farm products. Here again, the aim should be to equalise the rate of return on each project in all the three fields. The rate of return may be measured by the formula (X-Y) I, where

X is the social benefit;
Y the cost of agricultural output; and
I, the total cost of investment for irrigation

It will be adequate if the benefits are measured in terms of the net increase in the value of the newly added farm products. The methods suggested in the report appear to be useful and worthy of adoption although it may involve a good deal of investigation and study during the formulation of an irrigation project. However, a beginning should be made.

Pages 43 to 46 contain a brief note on indirect benefits. It is again emphasized that it is important to measure the benefits accruing from investment in irrigation to the economy as a whole. A rough estimate in the form of certain percentage increase of direct preliminary benefits is all that the necessary for getting an idea of the indirect benefits.

Chapter VI deals with the effects of irrigation, benefits and cost of irrigation and measurement of direct primary benefits; and describes the ex-post measurement of benefits of the Sarda Canal. The changes brought about by canal irrigation in the structure of the economy of the region served by the canal are briefly set out on pages 47 and 48. The effects of irrigation are primary and/or secondary. The primary effects may be classified as direct and indirect. The secondary effects emanate from the primary ones and spread in two directions, namely, (*i*) the increase in agricultural production leading to an increase in national income and (*ii*) the increase in agricultural income, having a multiplier effect on the rest of the economy. The direct primary benefits are measured as net benefits arising from newly added farm products, which can be measured by deducting the associated costs from the increase in the value of farm output. Two methods are proposed, namely, ex-post measuremant and ex-ante measurement. The ex-post measurement refers to the assessment of benefits actually accruing to a particular area as a result of the introduction of irrigation; whereas, ex-ante method refers to an estimate of benefits which are likely to accrue in a particular area if irrigation is introduced. The ex-post measurement demonstrates the practicability of the application of the criteria for investment in irrigation. However, it is the ex-ante measurement that is all important from the point of view of decision-making for investment.

In both the methods, the difference in regard to agricultural conditions in the same area under two different phenomena i. e. one in which there is supply of irrigation and the other in which there is no supply of irrigation or canal water, should be determined. Obviously, the ex-ante method assumes certain hypothe-

tical situation. The ex-post measurement involves the actual conditions prevailing before and after the introduction of irrigation in the same area or may refer to a comparison of conditions prevailing in two similar tracts, one of which is irrigated and the other unirrigated at a particular period. This method has been adopted in the case of the Sarda Canal. In this may method too, there are inherent difficulties. It may be difficult to find two tracts similar in all respects except in regard to the provision of irrigation facilities. An attempt may be made to compare the agricultural conditions prevailing in the same tract at two different points of time, having a difference of 20 to 30 years. A sample survey in the form of a farm management survey may be undertaken but it may be difficult to get reliable figures as cultivators do not generally keep accounts and conditions differ considerably from time to time.

The next important task is to find out the contribution of irrigation in terms of national income for any canal system. As mentioned above, this will be evaluated from the difference obtaining between different periods of time for a given area. Broadly, the changes in agricultural conditions as regards the yield, rotation of crops, crop pattern and net area cultivated should be assessed. If there is appreciable difference between the two situations, it may not be wrong to conclude that irrigation has been mainly responsible for the change. Another method is to select two adjacent areas in the same region, one with no canal irrigation and other with canal irrigation. The differance will bring about the contribution of irrigation. The third method is to conduct a small farm survey and ascertain how far irrigation makes a difference in regard to yield, crop pattern, cost of products, etc. It may not be reliable to arrive at any conclusion by adoption of any one single method. Since the aim is to get the feel of the magnitude of benefits from irrigation in order to make a qualitative analysis, a combination of the three methods mentioned above, may go a long way in giving fruitful results.

Coming to the secondary benefits and the indirect primary effects, the benefits to be measured are those arising from (*i*) processing, manufacturing and distribution of the increase in agricultural ouput; (*ii*) the multiplier effect of the increase in the income of the agriculturists arising from the direct primary increase in the value of the agricultural output; and (*iii*) the multiplier effect of an increase in income and investment on account of associate primary costs. These are more difficult of measurement as these benefits are likely to be more diffused and widespread. However, a simple method for calculating the contribution to national income arising from an index in agricultural output is described on pages 51 to 54. The steps involved in the measurement are set out in the middle of page 52. It is deduced therefrom that:

(*i*) net profits of the newly added farm products can be determined by deducting the additional or associated cost of inputs necessary to bring about the increase in agricultural output which will maximise the net profits on the newly added farm products, from the value of the expected increase in agricultural output ;

(*ii*) the contribution to the total national income will be equal to

(value of expected increase in agricultural output) × (the ratio between the total income and the income originating in the agricultural sector).

To illustrate this, an example has been worked out in the tables given in page 53. The results are interesting.

(*iii*) The total amount of inputs needed to obtain an increase in the national income will be equal to the sum total of the project cost, plus the additional or associate costs referred to in (*i*) above plus the additional or associate secondary cost of inputs necessary to bring about the increase in national income as a result of increase in the agricultural income.

The measurement of (*ii*) and (*iii*) above is required when it becomes necessary to allocate resources between irrigation and non-irrigation in which case all the techniques, namely, capital/output ratio, input/output ratio and benefit/cost ratios should be combined.

Detailed description of the ex-post measurement of benefits of the Sarda canal is given on pages 54 to 58. The main conclusions arrived at are that (*i*) introduction of canal irrigation has had no effect in so far as an increase in the area under cultivation is concerned; (*ii*) there has been an increase under sugarcane from 3 to 7% of the net area cultivated and (*iii*) the introduction of canal irrigation has made it possible to irriagate the land by canal instead of by wells or tanks. The table on page 57 sets out the results in quantitative terms. As regards the multiplier effects, it is observed that since the net benefits in terms of alternative costs have been measured, this question does not arise. The cost of investment may be more or less the actual measurement of benefits but the ex-post measurement has illustrated the manner in which the decision for investment on irrigation from the Sarda Canal has been made.

Fixation of Water Rates

Let us now move on to Part B (Chapters VII to IX) dealing with criteria for fixation of water rates. Principles for determining water-rates form the theme of Chapter VII. It may be true that in many cases water rates have not been fixed on a rational and scientific basis. Water rates vary from State to State and even from canal system to canal system in the same State. There may be thus multiplicity both in principle and in the scale of water charges. According to the report, they were more or less fixed on an *ad hoc* basis in the past. Regarding the case for increase in existing water rates, the old water rates, if applied to new projects constructed at enormous costs bring a much lower financial return and may put them in the category of 'unproductive' works. It is generally felt in certain quarters that owing to higher prices, the increas-

ed benefits arising from higher yields brought about by irrigation, have raised the paying capacity of the cultivators. The report emphasises the urgent need for a scientific enquiry into the whole structure of water rates prevailing at present so that it is put on a proper and rational basis. Unless the water rates are so fixed, their burden might fall inequitably on different users of irrigation waters. The method suggested in the report is fundamentally based on (*i*) cost; and (*ii*) benefits. These are examined in some detail on the lines on which an objective and rational criteria could be evolved or indicated.

The cost of a project should not be the only basis for working out the water rates. The Taxation Enquiry Commission (1953-54) expressed the view that the water rates on 'productive' works should include a charge for supply of water which will primarily cover the debt charges, the overhead expenses etc. On page 64, reference is made to the First Five Year Plan wherein it is stated that the water rate has no relation to the cost of supplying the water. It was also mentioned in the First Plan that since the cost of new projects are much higher than that of the old projects, there was a case for increasing the then existing water rates. It is observed that the Planning Commission "consider the revenue from water rates as an important source for recovery of costs of investment since the Government is still concerned with a financial productivity test" (page 64-65). Since more irrigation projects have to be undertaken in the future, the Planning Commission and the State Governments are naturally anxious to tap all possible and reasonable sources of raising additional revenues for developmental purposes. Commenting on the productivity criterion followed by the Government of India (p. 65), the report observes that the so-called productivity criterion as defined by the Govt. of India should not be continued to be adopted under the present conditions of the economic development in the country. It does not, therefore support the practice of selecting irrigation projects on the basis of recovery of cost. The reliance on recovery through water charges alone cannot be considered reasonable. According to the report, if the recovery of cost is to be insisted upon, the calculation should include not only the water charges and the share of land revenue, but also all such sources of State income which can be legitimately attributed to irrigation. By this method, it may be possible to reflect the productivity of a project on a better basis than the present one and may bring up the productivity rate of several irrigation projects and transfer some of them from the 'unproductive' category to the 'productive' one. Here, it may be pointed out that, although efforts are being made to make the irrigation projects financially sound, the yard-stick of financial return is, in most cases, not applied very rigidly. It is the broader considerations of conferring socio-economic benefits to the community at large which influence critical decisions on selection and authorisation of irrigation projects for implementation.

It is stated (page 67) that on canals where irrigation revenues can be increased by means other than through an increase in irrigation charges, the authorities are inclined to rely more on these charges rather than on other methods. What exactly is meant by 'other means' is not clear. It is possible that reference to betterment levy and other land taxes is made. The report further observes (p. 68) that "once the fixed costs are incurred, they cannot be taken into account in the determination of water rates." At the same breath, it goes on to say that " this does not mean that the fixed cost cannot or should not be recovered." Both these statements do not seem to go in harmony. One of the aims in fixing water rates is to meet, at least, the maintenance expenses and interest charges on the capital investment. A case for free supply of water is examined and rejected for the reasons given in pages 68-69 of the report. It is suggested that administratively it is more economical to mobolise the benefits of irrigation through a direct levy than through general taxation. The net benefit is claimed to be the only basis for fixation of water rates. How the net benefits to cultivators can be measured is briefly described. It is recognised that it is a difficult task to measure the quantum of additional net benefit available to the cultivators in a precise fashion. The following formula has been suggested for deriving this additional net benefit:

Additional net benefit owing to canal irrigation $=(R_2—R_1)—(C_2—C_1)$
where

(*i*) R_1 is the value of crop *before* introduction of irrigation;

(*ii*) C_1, the cost *before* irrigation;

(*iii*) R_2, the value of crop *after* introduction of irrigation; and

(*iv*) C_2, the cost *after* irrigation but *before* paying the water rates.

A question may be raised as to whether the entire net benefit can be attributed to irrigation. An answer to this would be that the cost of expenses ancilliary to the investment on irrigation should be deducted from the gross value of the produce from the land.

The considerations in fixing water rates are detailed on page 72. According to the report, water rates should be conducive to the most efficient utilisation of the irrigation facilities as soon as they are made available. It is linked with the regularity of the irrigation supplies and should be such as to offer sufficient inducement to the cultivators for the use of water. It should encourage the implementation of the national objectives or the State policy at any particular time. It would be useful if a clear picture of the crop pattern to be adopted under an irrigation project could be decided upon in advance. The State policy may consist in recovering the entire cost of the project or to keep the water rate at such level as would bring in enough to cover the working expenses and interest charges. The State may also decide to operate the project on a self-supporting basis. Another question that arises is what protion of the net benefit accruing to the cultivator should be recovered as water rate. As pointed out earlier, accurate measurement of additional net benefit is not an easy process and it would be better to

keep a safe margin in its estimation. The report recommends that whatever be the net benefit, the actual water rates should, in no case, exceed 50% of the extra net benefit available to the cultivator. The actual charge may range between 20% to 50% (p.74).

It is possible that due to high water rates, the utilisation of irrigation facilities may not be as rapid as it would have been otherwise. It is, therefore, argued that the minimum water rate is that which ensures full and rapid utilisation of the available waters. On page 74, the report examines whether water rate at the minimum should cover the operating expenses and whether performance of a project can be judged by the returns through the water rates. The report maintains that "the income through the water rate is no criterion for judging the performance of an irrigation project and hence the question is irrelevant." This argument does not seem to be convincing. It is further claimed that if the principle of net benefit is adopted, it may bring in enough revenue to cover not only the working expenses but also a surplus to meet the cost of amortisation. For this purpose, it would be necessary to evaluate the indirect benefits from an irrigation project.

It is recommended that free use of water or levy of a water rate at a low level in the initial few years should be encouraged in order to develop the irrigation facilities rapidly. This is already an accepted policy and has already been adopted in a few States like Andhra Pradesh, Bombay, Mysore, etc. where they have a graded system of water charges. As regards revision of water rates, the report suggests that the rates may be revised every five years, unless there is change in the price-level of more than 15% in which case the revision should be undertaken earlier. According to the report, there is no minimum level of water rates which can be fixed on the basis of cost. It is suggested that if, at a normally low rate, water is not utilised, it is still economical to lower the rate further till the water is fully utilised and the minimum water rate is, therefore, that which ensures the full use of water. Another point for examination is the extent of indirect returns to Government resulting from irrigation. The difficulty in regard to this is the evaluation of these indirect benefits. The paying capacity of the cultivators is also an important factor to be kept in view in the fixation of water rates as it will form an item of cost of production. In case, even after the irrigation, the cultivator's farm economy is left at a low level, it should not be a bar to charging him water rates. His problems should be tackled by Government through other means for improving the farm economy. Therefore the basis for fixation of water rates should, in actuality, be the poductive capacity of the farm, rather than the paying capacity of the cultivators.

Page 77 of the report briefly touches on the necessity to link water rates with other agricultural taxes. One of the suggestions is to levy a water rate on a gaduated basis by charging lower rates upto a particular size of holding which could cover a large stratum of cultivators of the lower level. The rates could be increased progressively on the higher slabs. The question of water rates is primarily a problem of mobilisation of resources of the rural sector and hence it should not be fixed in isolation from the land revenue and other agricultural taxes. The report does not recommend the charging of water rates on volumetric basis i.e. according to the volume of water consumed by the crops. The only exception is in regard to tube-wells and other irrigation devices. The report suggests that the net benefit principle may, therefore, be accepted as a sound basis for fixation of water rates, although it may be difficult in practical application. The main difficulty will be in the collection of data on yield, prices and cost of cultivation of various crops. Irrigation brings about a change in the crop pattern and this makes the work more complicated. Another alternative is that the value of crop may be taken as the basis for fixation of water rates. A high valued crop coupled with the high cost of cultivation may leave a lower net benefit than a lower value crop with a relatively much lower cost of cultivation. It is, therefore, concluded that the value of output cannot be taken as a basis for indicating the extent of additional net benefit available to cultivator after the introduction of irrigation. Nor is it possible to relate the value of output to the net benefit per acre. This leads to the conclusion that the value of output cannot be accepted as a basis for fixation of water rates. However, the value of the crop method could be used in areas where there is no cultivation before introduction of irrigation. Even in such cases, it will, perhaps be more appropirate to base the water rate on net benefit for each crop rather than on the gross value. Having regard to these factors, the water rate should be fixed at such a level as will bring in maximum revenue to the State.

Chapter VII deals with the manner of application of final form of rates, machinery for fixation of water rates, consitution and functions of Water Rate Boards proposed, as points of guidance therefore, Factors such as the nature of soil, type of crop, volume of water required, transport and market facilities and the net profits of cultivation involved in fixation of water rates are briefly touched upon. As mentioned earlier, there cannot be a uniform water rate for the whole country since conditions differ from canal to canal, and region to region. The procedure involves a primary agronomic and econonic survey of the region in order to enable the rate to be fixed for each crop and for each major soil class. The report suggests the formation of Water Rate Board for formulation of just and equitable system of water rates. The composition and the functions of the Water Rate Board are described in pages 82 and 83. In most of the States Development Committees consisting of the State Irrigation and Agriculture, Revenue, Cooperative and Community Development Departments, to ensure timely utilisation of the irrigation facilities, have been constituted. These Committees should also go into this question of fixation of water rates, etc. It does not appear necessary to set up separate Water Rate Boards. In some of the States there are standing Irrigation Development Committees or Boards at the State level and these could take care of the functions of the Water Rate Board suggested in the report.

Another important recommendation contained in the report is in regard to splitting up of the water

rates into two broad components, namely, (*i*) the compulsory levy irrespective of the fact whether water is actually used or not; and (*ii*) the voluntary rates for the actual water used. Compulsory levy should be low and be applicable to areas where supply of water is assured. It is suggested that the compulsory rate should be levied at 5 to 10% of the extra net benefit available the the cultivators. The voluntary rates may be fixed on the basis of actual water used. According to the report under discussion, the normal practice may be to charge 15 to 30% of the actual extra net benefit available to the cultivators, depending on the level of cultivation. Certain relief and remissions and concessions are suggested (p. 85). A significant observation is "that concession can be given to cultivators who adopt cooperative farming or demand water for on a cooperative basis." Three steps are suggested for efficient utilisation of water. These are:

(*i*) The Irrigation Department should supply irrigation water at the right places, at the right time and in the right quantity.

(*ii*) There should be a liason department to act as a link between the cultivators and Irrigation Department.

(*iii*) There should be a research and demonstration unit.

The application of the foregoing principles to the Sarda canal, the demand for water in the area, supply position, system of distribution of water, the irrigation record of the canal, efficiency of utilisation of water, the irrigation rates obtaining in respect of the canal, the revenue position thereof, forms the subject matter of Chapter IX. How uniformity of rates in different regions cannot be justified, the need for lower rates in new areas and how the present water rates are not related to the gross yield from the Sarda Canal irrigation are also explained. The relationship of the present rates to the extra net benefit flowing from the canal is briefly described in the concluding portion of the chapter. Certain critical remarks have been made on the operation of the canal. It is stated that the cultivators could not get canal waters at the time they most need it and the distribution of water was often irregular, uneven and sometimes inequitable (p. 88). According to the report, there also appears to be disparity in the supply of water; the condition and maintenance of the guls (water courses leading to the cultivators' fields) and the kulbas (pipes for distribution) leave much to be desired. The bad condition of the guls is stated to be a major factor responsible for inadequate utilisation of the canal waters. It is also alleged that the contact between the cultivator and the irrigation administration is unsatisfactory. Actual area irrigated under the canal even after 25 years of operation works out to only a little over 50% of the area irrigable. Evidently, full use is not being made of the available irrigation facilities. This had, no doubt, an unfavourable effect on the financial position of the project. It is essentially for U.P. Govt. to reply to these criticisms.

Water rates on the canal have remained unchanged in the first 5 years after which the rate for sugarcane war raised. The rates had not been changed substantially till 1944. Since then there has been an increase of about 50% in the rates including an increase of 50% in 1950 and a further increase of 50 to 100% in 1954. Subsequently, a rebate of annas 3 in the rupee was granted on the irrigation charges. Today, the rates are stated to be about 200% of the pre-1948 rates. The feeling that water rates are heavy may largely disappear if the canal could meet the needs or demands of the cultivators in time and to their satisfaction. It is observed (p.97) that there has been an increase in the land revenue receipts by Rs. 3.71 lakhs per annum. This contains an element of indirect benefit to Govt. owing to irrigation facilities, besides other factors which may be responsible for the increase. However, the Sarda Canal system has been showing a net loss, the actual extent of which has been declining from year to year. However, the financial position took a turn for the better from the year 1953-54 and showed a net profit of Rs. 50 lakhs in 1954-55. Perhaps, this was more due to the increase in the water rates which took place in 1953-54, rather than to any increase in the irrigated area. The financial position again became weak in 1955-56. The table on page 103 gives the net benefit on irrigated and unirrigated plots in the Sarda Canal area in 1957-58. It is interesting to observe therefrom that the present water rates expressed as a percentage of the extra net benefit comes to about 21% for wheat, 23% for paddy and 21% for sugarcane. It is generally concluded in the Report that the net benefit owing to irrigation, would be higher than indicated by the above figures if the utilisation of water is improved.

Summary and Conclusions

Chapter X gives a summary of the main conclusions and the recommendations contained in the report. The more striking ones therein are briefly brought out in the paras that follow.

Investment Criteria: The factors governing investment in irrigation are summarised as under :—

(*i*) Adequacy of funds for investment in irrigation as against non-irrigation ;

(*ii*) The distribution of the given funds for irrigation among major, medium and minor irrigation schemes;

(*iii*) Selection of projects inter se ; and

(*iv*) The scale of investment for each project.

It is stated (p. 107) that there are no clearly defined investment criteria for irrigation works in India. This does not appear to be correct. The irrigation policy and considerations for inclusion of projects in the Plan are fully explained in the two reports on the First and Second Five Year Plans. These are being followed to the extent possible, taking into account the overall need for increase in food production, balanced regional development in the country etc. It is further stated that investment decisions are taken on an *ad-hoc* basis. Here again, the considerations mentioned above influence largely the selection of irrigation projects and the financial productivity test, it would appear, has

not been too rigidly applied in such selection. It is observed (p. 108) that the financial productivity test is actually restrictive and leads to adverse economic consequences at every stage of an investment decision. It is further claimed that the case study of the history of the Sarda Canal in U.P. amply demonstrates that the formulation of the scheme, the timing of investment and the distribution of water to cultivators have been adversely affected by this restrictive view point.

There are several considerations which make it imperative to proceed with irrigation development on a larger-scale in different parts of the country and the traditional financial productivity tests may not be satisfactorily met by a large number of irrigation schemes taken up for execution. There appears to be no simple solution to this problem. It needs to be recognised that the fulfilment of the financial yardstick may not be the last word on the subject of selection of irrigation projects, In the context of rapid economic development, they would appear to serve only a limitted purpose. The main queestion that may be considered usefully is the kind of balance which can be struck during each phase of development between irrigation and other fields of development. In choosing irrigation projects *inter se*, however, the financial yardstick may be of some value as a tool in planning. The statement in the report that the restrictive investment criteria cannot be justified in the context of the present economic and social policy of India, appears to be correct.

Another significant fact which emerges is that any attempt to devise an ideal method of resource allocation may largely be a matter of judgement. A choice of any one technique or a combination of various techniques such as the input/output ratio, the capital/output ratio, social benefit/social cost ratio etc. depends on the availability of adequate data and information and the extent to which planning controls such allocation of resources available in the country. The technique of social benefit/social cost ratio is defined as follows:

The marginal social benefit of technically possible increment must be equal to the marginal social cost and the ratio between marginal social benefit and marginal social cost must be the same for all investments.

This is, no doubt, a theoretical ideal and certain modifications may be necessary in its actual application in practice. As regards the steps involved in the measurement of social benefits and costs, it needs to be pointed out that precise studies on the duration of project life and extent of risk involved, etc. do not appear to have been so far undertaken in our country, as is done in a detailed fashion in U.S.A.

As regards allocation of funds among major, medium and minor schemes, the report suggests that it should be made on the basis of the net profits of the newly added farm products or on the basis of the direct primary effects from a project.

The selection of projects *inter se* is to be made on the basis of direct primary benefits of the project and that project should be selected which gives the highest returns. The determination of the scale of investment for each project is to be made on the basis of the rule that the value of marginal benefit /marginal cost should be unity.

Criteria for Water Rates: Water rates are neither uniform nor dotheir variations have any scientific basis. It is recommended that the water rates should be fixed on a sound basis.

The principle that a project should bring in certain monetary return on the capital outlay through water rates cannot be justified. Recovery of amortisation or operating cost is no sound basis for fixation of water rates. The only sound basis for fixing irrigation rates is the net additional benefit arising out of irrigation. However, water rates should be pitched at such level as will bring in maximum revenues to the State. The actual water charges may vary between 20 to 50% of the net benefit accuring from the provision of irrigation facilities.

The report recommends compulsory and voluntary water rates. There should be graded system of charges in the initial stages of operation of a new project so that the development of irrigation may take a rapid stride. Water Rate Boards should be set up for each region or State to collect the necessary data and fix the rates.

The appendices contain a number of statistical data on the method of measurement of social cost used in Taiwan; measurement of benefits of irrigation. It also includes a note on the sources of statistical information contained in the Report.

Before closing this review it must be gladly acknowledged that the treatment of the subject in the report is most excellent and intensely thought-provoking. Whatever comments and views have been advanced in this review are the author's own and not necessarily of the organisation or the Government in which he serves.

A Correction

On page 38 of the October issue of the Indian Journal of Power and River Valley Development Mr. A. K. Sen's name has been erroneously printed as Mr. S. K. Sen in the news item. We very much regret the same.

Economic Utilisation of Irrigation Water

By A. G. MIRAJGAOKER

Every year millions of rupees are being spent on the major and minor irrigation projects in our Five Year Plans, for harnessing the water resources of our country to increase food production. Uptil now, more than 150 million acre feet, out of the total water wealth of 1350 million acre feet, have been utilized to irrigate 67 million acres, out of the total 316 million acres of land available for cultivation. By the end of the Second Five Year Plan, an additional area of 20 million acres is proposed to be brought under irrigation.

To plan for becoming self-sufficient in food production, it is necessary to compare the demand with the supply for the next 15 or 20 years. The rate of increase in the country's population is alarming. At present, the population of India stands at 362 millions and the rate of increase shows that it will rise to 492 millions by 1975 i.e. after about twenty years. The present rate of increase in population is far more than the rate of increase in food production and it looks that we will not be able to do away with food imports, unless there is a tremendous increase in irrigated area and food production.

Increase in irrigated area could be achieved in two ways; firstly by expanding our irrigation system by constructing new irrigation works and secondly by economic utilisation of irrigation water available. At present large quantities of water are being wasted due to evaporation and seepage in storage reservoirs, conveyance system and application methods. Water, which is being wasted due to evaporation and seepage could be utilised for additional irrigation if the wastage can be avoided and the water application methods are improved.

The present paper is an attempt to discuss the economic utilisation of water by minimising the losses and improved irrigation methods.

Loss of Water from Reservoirs and Canals

Large irrigation works have been built in our country in the past hundred years. There are as many as 30 reservoirs, big and small, and more than 50 diversion head works. A length of nearly 66,400 miles of canals, taken from the reservoirs and headworks, carry about 400,000 cusecs of water to the fields. From these reservoirs and canals there is an enormous loss of water due to evaporation and percolation. Evaporation losses are more in reservoirs because of greater exposed area and the percolation losses are more in canals due to longer lengths.

Every year, about 5 to 6 feet of water depth is lost from reservoirs due to evaporation alone, depending upon the climatic conditions. This means that, there is a loss of 5 to 6 thousand acre feet of water from every thousand acre of reservoir waterspread. It could well be imagined as to how much water is being lost every year, from the thousands of acres of waterspread of all the reservoirs in India.

In canals, the water loss is mainly due to seepage and percolation from the wetted perimeter, and it is estimated that about 10% to 50% of the total quantity of water is lost in seepage. Shri Kanwar Sain, has estimated that even taking an average rate of 25%, the total loss of water from canals works out to 100,000 cusecs. With a duty of 100 acres for half of this discharge and 200 acres for the rest, an area of 15 million acres could be irrigated with this water, which is being lost boy seepage every year.

Measures to reduce Evaporation and Seepage

There are several methods of reducing evaporation losses developed in U.S. and Australia. One of these methods is to keep the water surface area as small as possible, while designing the reservoir itself, either by proper planning and operation of the reservoir or by having a network of reservoirs so that the water surface area is comparatively smaller. One more method is to spread a monolayer of oil film over the entire surface of water so that the evaporation is retarded. Oil, which has got a higher melting point than water and is lighter than water, keeps floating over the water surface and does not allow the heat of the sun to come in direct contact with water. Experiments in foreign countries, have shown that the evaporation losses could be reduced to as much as 90% by this method of spreading oil film and at the same time it is not very costly as well. Proper type of oil to form such monolayer is under investigation. In Australia, they have tried Cetyle Alcohol for this purpose and got satisfactory results. Hexadecanol, which is a bye-product of whale oil, has also proved to be very successful.

In our country, however; nothing has been done towards reducing evaporation losses from reservoirs. It is suggested that C.W. & P.C. should take up this problem of finding some type of material suited for Indian conditions and save this great loss of national wealth.

Seepage and percolation losses can be greatly reduced by lining the canals with some suitable material like cement concrete, bricks, tiles, precast cement blocks soil cements, bitumins etc. The proper type of lining material depends upon the availability of that material in the vicinity, its water proofing properties, etc. The cost of lining canals is always more in the first instance but ultimately it proves to be very economical as it saves water from percolating deep into the ground. In

addition to saving of water from seepage, lining improves the hydraulic properties of the canals permitting economical designs, greater allowable velocities resulting in minimum or no silting and weed trouble, minimum loss of head which is particularly important in power canals, no waterlogging trouble in the adjacent lands resulting in more cultivable area and on top of all, least maintenance expenditure. The benefits of lining have been fully recognised all over the world and in almost all new irrigation and power canals, lining is being resorted to. The economics and advantage of lining can be very well studied on the Tungabhadra, right bank and left bank canals, in Mysore State. One of the canals is entirely lined and the other one is entirely unlined.

It is suggested, that instead of expanding our irrigation canals, it would be worthwhile to improve the existing canal system first by properly maintaining them, redesigning them if necessary and lining them with some suitable material so that the present excessive wastage could be minimised and the quantity of water thus saved could be utilised to bring more land under irrigation. An all-out effort should be started towards improving our present canal system and it will certainly add to our present food production without much additional expenditure.

Economic use of Irrigation Water

Efficient and economic use of irrigation water reaching the fields is very important. In an efficient irrigation system, it is essential to distribute water uniformly in order to avoid excessive deep percolation loss on one part of the field and inadequate wetting of the soil on the other part. The objective in each irrigation is to moisten the soil fully, without permitting excessive deep percolation from the root zone soil. Water is the national wealth and it should be very carefully utilised by the cultivators. The aim of every cultivator should be put every cubic foot of water to its maximum advantage.

For effecting economical use of water, improvement in the present water distribution methods is necessary. Secondly, introduction of volumetric system of assessment is also essential in which case the farmer uses water very carefully as he has to pay for every cubic foot of water taken by him. Thirdly, there is a need to study the crop patterns and adopt such crop schemes that the moisture of one crop helps the succeeding crops. Fourthly, study of "Consumptive use of Water" will also help in understanding the actual water requirements of crops to give a good yield.

Irrigation Methods

Water can be applied to land in four different methods namely (*i*) flooding the surface (*ii*) furrow irrigation (*iii*) sub-irrigation (*iv*) sprinkler irrigation. The first two methods of irrigation are known and practiced in India, but our cultivators have not yet heard about the other two.

In applying water to the soil by flooding or in furrows, the irrigator attempts that enough water should prercolate into the soil to moisten it fully upto the root zone while the sheet of water is flowing over the land surface. When a large quantity of water is applied to a soil of low infiltration rate, excessive surface run off occurs whereas in soils of high infiltration rate, greater quantity of water is lost in deep percolation as a contribution to the ground water table. The addition to ground water may help the enlargement of natural springs but, for the crops, it is a shear wastage, sometimes resulting in water-logging making the land useless for cultivation.

It has been found that much less water need be applied to the farms to produce profitable crops than believed necessary. The quantity of water needed to moisten the root zone can be estimated beforehand. If a cultivator knows the quantity of water applied to his field during a certain time, he can calculate the depth of water in that watering. If Q is the quantity of water applied in cubic feet per second, A is the area of the plot in acres, T is the time and D is the depth of water, then a simple relation can be given as :

$$Q.T = D.A$$

with any three quantities known, the fourth one could be calculated from the above equation. Suppose a discharge of 2.8 cusecs is flowing over an area of one acre for 4 hours, then by the above equation, it could be found that the depth of water would be 11.2 inches. As the root zone of crops extends upto 4 to 5 inches below the ground, it can be noticed that a depth of about 6 inches is being lost in deep percolation without any particular benefit to the crops. After this calculation, the flow or the time rate could be modified so as to reduce this wastage of water.

The above calculation is simple and the cultivator could be taught to work out the quantity of water needed, so that he could do the necessary regulation. There should, however, be the necessary measuring devices in the fields by which he can measure the flow. In the above example, it is assumed that the evaporation losses would be small and hence they have been neglected.

Sub-irrigation is process of applying water below the soil surface through various kinds of pipes and conduits. Under favourable conditions, sub-irrigation may be feasible for the production of high priced crops on small areas. The soil condition should permit free lateral movement of water in the root zone and a very slow downward movement in the sub-soil. The sub-irrigation has not proved to be economical as it involves laying of perforated pipe network below the soil surface and other elaborate arrangement to see that water flows only in the root zone and at the same time there is no choking of the pipe lines etc.

In sprinkler irrigation, water is applied to the crops in the form of spray as in ordinary rain. The sprinkler system comprises of sprinklers, the riser pipe, the lateral distribution pipes and pumping plant to give the required pressure. Water comes out from the sprinklers like a spray and falls on the crops. Sprinklers can be either fixed or rotating and the entire system can be portable too. Portable sprinklers are

very useful to irrigate field crops because the entire arrangement could be shifted wherever necessary.

Sprinkler irrigation is particularly useful to irrigate soil of high infiltration rates and over areas having steep slopes where flooding or furrowing results in excessive erosion. Sprinklers permit greater control on the quantity of water applied, save the labour of preparing the land by grading and also save the land needed to make furrows. Due to its many fold advantages, the sprinkler irrigation is becoming increasingly popullar in foreign countries. We in India should also try this new method of irrigation. Initially it could be attempted on governmental farms to study its economics in comparision with the existing irrigation methods. If found suitable for Indian conditions, our cultivators should be advised to adopt this system. Its initial cost may be more but it should prove economical in the long run.

To improve irrigation techniques, the farmers should be properly educated. In the adult eduction classes the need of improved irrigation methods and the economy effected thereby should be stressed. Occasional exhibitions and imformation films will be very helpful in this direction.

Consumptive use of Water

The consumptive use of water is defined as the volume of water absorbed by the crops and transpired or used in building the plant tissue together with the volume evaporated from the adjacent soil. During the growing season of the plant, water is both transpired and evaporated. It is thus consumed from that area. The consumptive use of water depends on various factors such as temperature, humidity, wind velocity, rainfall, length of the growing season and irrigation practice. Comprehensive studies of consumptive use of water are essential to find out the actual quantity of water required by the crops to give good yield.

There are various methods of determining the consumptive use of water for a particular crop under particular conditions. One of the field methods is to study the water requirement of crop for a number of seasons and observe the yields at different water supplies. With the increase in water used, the yield increases rapidly to a certain point and then either it decreases with further increase in water supply or the increase in yield is insignificant. That quantity of water which gives maximum yield under a particular set of conditions is the "consumptive use of water" for that crop in that area. While conducting such experiments care has to be taken to see that percolation losses are minimum and the rainfall quantities are also accounted for.

In our country, the study of consumptive use of water has not been made as yet. It is very important for determining the actual water requirements of crop to give good yields. It would be worthwhile that in every irrigation sub-division, there should be one section to undertake the experiments of consumptive use so that the farmers could be advised from time to time as to how much quantity should be applied in each season.

System of Assessment

In our country the farmers are required to pay the water charges depending upon the area they irrigate, without any consideration to the quantity of water taken by them. This system is known as the area basis of assessment and is prevalent in our country. The farmers do not care as to how much quantity of water they are taking. They allow the areas to be flooded without any consideration of the crop requirement. This not only results in great wastage of water but the excess of water results in water-logging of land on which cultivation becomes impossible. It is absolutely necessary, therefore to change our present system of assessment to the volumetric basis in which the farmers are charged according to the volume of water they take. They will then be very careful in using every drop of water because they have to pay for the quantity of water they take.

In the lift irrigation, for instance, in the tube well irrigation, the volumetrie basis of payment is already in vogue. It is a common experience that farmers taking tubewell water, use it very carefully than those getting the canal water.

Volumetric system will force the cultivators to be economical and it will certainly result in great saving of water which could be utilised to irrigate additional land. Devices like notches, venturiflumes and Parshall flumes may be used for measuring the quantity of water given to the farmer.

Conclusions

The need for economic use of irrigation water can not be overstressed. In this paper, the wastage of water in storage reservoirs, canals and in actual use by farmers, has been discussed and methods are suggested to reduce the wastage. The measures to effect saving in water could be summarised as below:—

1. Improvement of the existing canal system, should be given priority in all irrigation departments over constructing new canal systems. Existing canals should be properly maintained, lined if necessary, with some suitable material and redesigned to serve additional area.

2. The present system of irrigation should be improved and the wastage of water be minimised. Use of sprinkler irrigation should be tried as an experimental measure on government farms to study its economics under Indian conditions and the farmers be advised to use this method.

3. The 'consumptive use of water' by crops be carefully studied and the cultivators be advised from time to time regarding the optimum water requirements to give good yield.

4. Volumetric system of assessment should be introduced instead of the present area basis of assessment. The farmer will then be very careful in the use of water.

5. Farmers should be educated to adopted new and economic methods of cultivation in their adult education classes. Occasional exhibitions should be arranged and information films be shown to them for improving their techniques.

[*Continued from page 2*

FINANCING POLICY FOR PUBLIC UTILITIES

as a fraction of a penny per kilowatt hour on the electricity bills of Kariba's many and diverse customers.

The case for making other utilities, like railroads, contribute capital from their own earnings for their own expansion is, I grant you, not so simply put. But, as the Indian railways show, there are great benefits to be had if these services can be financed outside the regular budget. As far as railroads are concerned, it can be said at the very least that direct subsidies for operating expenses from government revenues almost always represent an expensive luxury for a developing country. Any unnecessary or excessive expenditures on the provision of essential railway service, even if they can be financed without inflation, can only mean less resources available for real development needs and for job-producing investment.

The strain on a developing country of the doctrine of artificially cheap power rates is bad enough. When the costs of other utilities are kept artificially high through what President Frondizi has called "bad organization" or "an excess of administrative personnel," the strain may well become intolerable. Make no mistake about it; the strain falls not upon any small group of people who might be able to bear it; it falls upon those least able to bear it—those whose standards of living are most susceptible to inflation, those who pay the general excise taxes which most governments in developing countries rely on for the bulk of their domestic revenues. When these strains are justified as a means of accommodating commerce and industry, it simply amounts to soaking the poor to subsidize the rich.

If I have stated the case for sound utility finance in emphatic terms, it is only because I feel it hard to exaggerate how important this issue is to continued economic growth. I do not mean to minimize the great difficulties member governments face in trying to move from where they are now to such a position. We are not, after all, starting from scratch; everywhere there are more or less heavy legacies from the past to overcome which make it impossible to correct bad financial practices overnight. The problem is to get from where we are today to a position better suited financially for the long pull ahead.

Still the enormous sums, from domestic savings and from foreign investors, which are needed to keep utility services abreast the rapidly rising demand, make it imperative to discard old-fashioned, emotional attitudes towards utility finance and substitute common sense economy. This, in turn, means adequate rates; it means the prompt adjustment of rates at times of rising costs; it means realistic valuation of assets and normal depreciation allowances. If these sound like strange slogans with which to rally people in search of a better material life, they nonetheless go to the heart of the matter. I congratulate those leaders in member countries who are speaking out so courageously for the right to make utilities pay their own way. They are pointing out one unavoidable requirement for escaping the mass poverty which is our common enemy.

By singling out utility rates and their special relation to economic growth, I do not mean to leave the impression that all economic development can be reduced to this. Utilities are just as often the victims of inflation as they are the cause of it. And the gathering momentum of development in many member countries makes urgent a whole rage of measures for financial stability if the resources which are available—domestic and foreign—are to lead to the higher living standards we all are working for.

In the Bank we stress these special matters because we want to see this race run to the finish. With so many countries now in full stride, it is tremendously important that we don't put unnecessary hurdles in our way, that the track be kept clear so economic growth can continue to gather speed. We in the Bank do not feel we are on the sidelines in this race; we feel we are running with each one of you. We are not disinterested obsevers, but partisans who want to win just as much as you do.

BOOK ON DESIGN AND CONSTRUCTION OF CYLINDRICAL SHELLS

The National Buildings Organisation is shortly publishing a book on "Designs and Construction of Cylindrical Shells" by Dr. A. Carbone, Consulting Engineer, Calcutta, and Professor G. S. Ramaswamy, Assistant Director and Head of Division of Concrete and Structure, Central Building Research Institute, Roorkee.

The book presents the subjects from the fundamentals and unlike other books on the subject it does not assume a knowledge of advance mathematics on the part of the reader. The book is written to meet the needs of the designer, engineer on the job and student interested in the subject.

The book is divided into four parts. Part I introduces mathematical techniques which are a prerequisite for the study of shell structures with several illustrative examples. Part II is devoted to a comprehensive treatment of 'Membrane analysis' explained with the aid of worked examples. In Part III, 'Edge-disturbance Theory' is presented with unusual clarity followed by worked examples on cylindrical and north-light shells. The fourth and concluding part deals with practical aspects of design and construction.

This book written by two experts with wide experience should be useful to the engineer and the architects.

Technical Notes & News

Coal Conservation Policy

The 25th Annual General Meeting of the Geological, Mining and Metallurgical Society of India was held in Calcutta in November, 1959. Mr. J. N. Mookerjee delivered the Presidential Address and Prof. Humayun Kabir, Minister for Scientific Research and Cultural Affairs, Govt. of India, was the Chief Guest.

Serious Shortage of Coking Coal predicted

In the course of his address Mr. Mookerjee stated:

The position of coking coal day is this : Our resources are admittedly low. In spite of all our exploration activities, we have not come across any new deposits of coking coal, although we have found many new and large resources of non-coking or steam coal. There has been no reassessment of the resources of coking coal since the publication of the Report of the Metallurgical Coal Conservation Committee. At the same time, our target for steel production is bound to be high. We have plenty of high grade iron ore and other raw materials necessary for making steel. Our only handicap is a likely shortage both of reserves and of the actual production of coking coals. About reserves, the Metallurgical Coal Conservation Committee's report is our latest authority; about production, difficulties are already being experienced about the supply of coking coal to the steel industry and, at this rate, a shortage seems more than likely at the end of the Second Plan, when all the steel plans are expected to be in full production. This shortage will be there even after diverting all the coking coal, including all semi-coking and blendable coals, from railways and other consumers who were hitherto using this coal because the steel plants were not there. In the Third Plan we are thinking of an additional steel production of 4 million tons with another 1 million tons of pig iron. The additional production of coking and blendable raw coal that will be required in the Third Plan would therefore have to be nearly 12 million tons. In order to attain the level of industrialization of other advanced countries, we will certainly plan for more and more steel production in the Fourth and Fifth Five-Year Plans requiring a progressive increase in the production of coking coal. As far as can be seen today, this will present serious difficulties The alternative will be to import coking coal. The cost of such imported coal will be heavy and will not only put us in a difficult competitive position as to the cost of production and price-structure of steel, but we must also find the foreign exchange for buying this valuable raw material. It follows, therefore, that we must try and produce as much of coking coal as we can with a view to reducing, if not altogether eliminating, the import of coking coal.

Mr. Mookerjee suggested, *inter alia*, the following steps:

All new mines producing steam coal should be large units of production and every colliery should have its own washery. Thermal power stations should be installed near every colliery to use the middlings. It is likely that there will be more middlings from non-coking coals than from coking coal washeries. Thermal power stations should, therefore, be designed accordingly. Central washeries should be installed at depot stations and thermal power stations near the central washeries. Only clean coals from the washeries should be allowed to be carried by rail and middlings should go to the thermal power stations. Rejects may be used for stowing in coal mines. It follows, therefore, that in view of the inferior quality of our coals and the large quantities of middlings that are likely to be released and the thermal power generated out of it, a large part of our energy requirements must be drawn from electric power. Electrification of the railways and industries should be the order of the day.

What Research can achieve

Prof. Humayun Kabir in the course of his speech said, that "the physical and chemical surveys undertaken by the Central Fuel Research Institute reveal that some of the coalseems which were hitherto considered unsuitable for metallurgical purposes are in fact potential sources of coking coal by beneficiation and processing. This favourable finding has been partly offset by an unpleasant discovery revealed by deep drilling in the Jharia coal fields by the Geological Survey. This seems to indicate that some of the seams that we expected to be of good coking quality have been burnt out by igneous intrusions. In this situation, it seems astonishing that out of an annual production of about 13 million tons of coking coal, as much as nine million tons should be used by railways and industries that can use non-coking types. Our immediate concern must therefore be to find means of conserving coking coal without sacrificing efficiency. Here the work of the Central Fuel Research Institute has indicated some reasons for hope. It has been found out that large reserves of high ash coking coals can be carbonised after beneficiation by washing, and some of the semi-coking coals, specially from Raniganj and Karanpura coalfields can be blended with different proportions of coking coal to yield the desirable quality of metallurgical coke. Improvements in mining methods and provision of sandstowing are also expected to increase our mineral reserves".

Shri Kabir referred to the blending arrangements made at the

coke ovens of the steel projects at Bhilai, Durgapur and Rourkela at the insistence of the Institute. He disclosed that as a result of these arrangements there has been considerable economy in the use of fuel. He said, "the Durgapur Steel Plant has accepted a blend of 75 per cent of high volatile Raniganj coal thus leading to a saving of about Rs. 5 million a year in freight alone and approximately Rs. 2½ million in cost of washing. The Bhilai Steel Plant has found ways to utilise 20 to 40 per cent of local coals leading to an annual saving of five to ten million rupees in freight alone. At Rourkela, the results of the Institute's work on survey, preparation and carbonisation studies on coal of the Kargali seam indicate that the entire needs of the plant may be met locally from coals that have till now been used only for locomotives. It is also estimated that as a result of low temperature carbonisation, 15 to 20 per cent of the fines will be suitable for blending with the semi-coking high volatile coals of the Raniganj field for the production of metallurgical coke. The Institute has also solved the problem of washing the mixed different coals produced from a large number of small mines, a problem which I am told has till now been considered insoluble by many foreign experts.

Besides, the use of a substantial proportion of substandard coals for coking in all the steel plants in the public sector, some new methods are being tried out which may lead to considerable economy in the use of fuel. The adoption at Rourkela of the L.D. process which is one of the most successful oxygen using techniques for the production of steel may have a great influence on the future expansion of the steel industry in the country. It not only produces a high quality steel at a higher rate of production with decreased fuel consumption but involves comparatively lower capital and operating costs. In addition, it provides a large amount of surplus gas for utilisation in the fertiliser plant. Similarly, the use of sintered ore and high top pressure in the Blast Furnaces at Bhilai are expected to lead to improved efficiency by increasing output of iron with a lower consumption of coke.

Attempts are being made in important countries of the world to find out alternative methods of iron making by utilising non-coking coals directly for smelting iron ore. Among such processes the Wever process developed in Germany deserves special mention. In this process, fine coal is briquetted with pulverised iron ore and the resulting briquette is smelted in a lower shaft furnace with or without oxygen enrichment. A low shaft furnace pilot plant has recently been installed in the National Metallurgical Laboratory to investigate the application of this process to Indian conditions.

It has shown that electricity can be generated from the worst quality and the smallest sizes of coals available in the country and particularly from those that are unsuitable for use in orther plants. Efficiency of operation will, however, be doubled if not trebled if this is done and power produced by inferior coal utilised for locomotive traction.

Greaves Cotton Completes 100 Years

Established as James Greaves & Company at Broach in the year 1859, the firm of Greaves Cotton & Co. Ltd., can look back with pride on a century of progress in the course of which they have earned the reputation of being one of the foremost engineering concerns in the country. Although originally, they began with the buying and selling of cotton, they soon started importing textile machinery and establishing ginning and pressing factories and later, spinning mills of their own. By 1883, they could claim to be among the largest owners of spinning mills in the world. They gave up their spinning interests during the first world war. The Company was converted into a Limited Company in 1922 and concentrated on the import of machinery, electrical equipment, metals and sundry merchandise. Parallel with the technical sales organisation, an expert after-sales service was developed. With Greaves, the policy has always been "Know your Product, Know your Customers' needs, and whenever possible, anticipate those needs". This has meant extensive touring throughout the country by Greaves' Engineers to study customers' requirements and to demonstrate how Greaves' products could meet them adequately. In this connection, mention must be made of the pioneering effort made by Greaves in demonstrating the great advantages of mechanising fishing vessels and other country craft. Also in the early days of aviation in India, it was Greaves who demonstrated how many different types of cargo could with great advantage be carried by air.

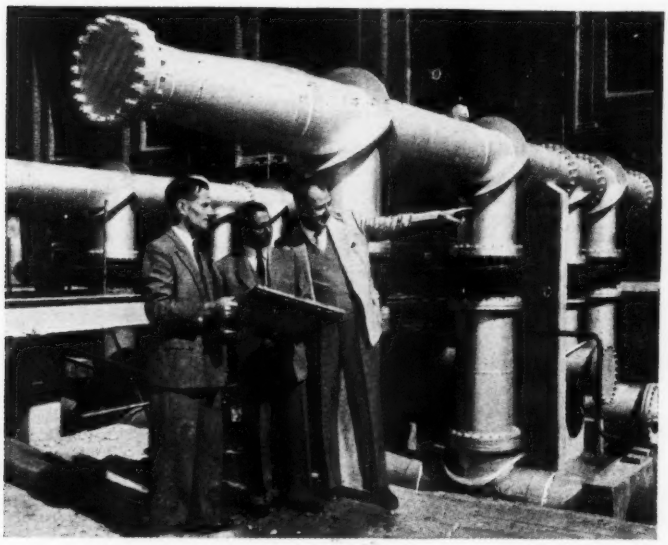
In 1937, Crompton Parkinsons of England joined with Greaves Cotton and the Associate Company of Greaves Cotton & Crompton Parkinson was started with the object of handling all the Electrical agencies hitherto handled by Greaves Cotton alone. At the same time Crompton Parkinsons decided to manufacture in India and the manufacturing Company Crompton Parkinson (Works) limited was formed for this purpose. Today Crompton Parkinson (Works) Private Limited is an Associate of Greaves with two Works in Bombay and Greaves Cotton & Crompton Parkinson handle the sale and service of the products from the Works. The Crompton Parkinson (Works) manufacture a veriety of electrical equipment including Electric Motors, Motor Control Gears, Switchgear and Transformers.

Two years later, in 1939, with the financial and technical co-operation of the famous English company of Ruston & Hornsby Limited, the manufacturing Company, Ruston & Hornsby (India) was formed for the indigenous manufacture of Diesel Engines and Pumps. To these manufacturing ventures have since been added Kenyon Greaves Private Limited, who manufacture inter-stranded ropes, Greaves Dronsfield Private Limited, who manufacture the famous Atlas brand Emery Fillet and

Greaves Foundry Services Private Limited, who manufacture a variety of Foundry fluxes under the technical guidance of Foundry Services International Limited, Birmingham. In their own workshops, Greaves Cotton manufacture paper cones and tubes for the Textile Industry. Plans are afoot for manufacturing many further lines which have already acquired a reputation in India. Among these must be mentioned Ruston Verticle air-cooled Diesel Engines for marine and industrial applications, David Brown Radicon Worm reduction Gears, Mather & Platt Calendar Bowls, Dratyon Steam Traps and Mindrill Diamond Drilling bits. In all these projects, Greaves have the advantage of both the financial and technical collaboration of the foreign manufacturers.

Greaves have also built up an efficient Aviation Division, which maintains close liaison with all aviation interests in the country on the one hand and British manufacturers on the other. Greaves are Sole Concessionaires for Bristol Siddeley Engines Limited, whose 'Orpheus' Turbojet engine is being manufactured in the Hindustan Aircraft factory at Bangalore. The Aviation Division have a number of new manufacturing proposals which are under examination. Always looking further ahead, their staff has been gaining experience in the fields of Electronics and Guided Missiles, ready to play their part in assisting the further development of these lines in India.

Greaves Cotton & Company is completely Indian, a Public Limited Company with over four thousand shareholders, managed by a Board of Directors with Lala Karam Chand Thapar as Chairman. Today the Company continues its march onward to a second century of further progress studying the country's requirements, exploring possibilities of further collaboration with foreign capital and technical know-how, making its own contribution to the industrial development and prosperity of the country.



Mr. S. R. Ghose, superientending engineer from the Damodar Valley Corporation project, is visiting Australia under the Colombo Plan, to gather information on the construction, operation and maintenance of water supply and irrigation projects.

Mr. Ghose inspects the installation of new water distributor head pipes at the Ryde pumping station, in Sydney. The engineer-in-charge, Mr. R. Cody, left, and Mr. W. Guest, are explaining plans to him.

A. D. Benham

Mr A. D. Benham, M.B.E., M.S.C., B.E., BM.I.C.E., M.N.Z.I.E. Investigating Engineer (Hydro) for the New Zealand Ministry of Works, has been appointed a Professor of Engineering at the newly established South-East Asia Treaty Organisation graduate school of engineering, Bangkok.

Mr Benham won the highest award of the New Zealand Institution of Civil Engineering, the Fulton Medal, for his 1950 paper on the results of fundamental research in hydrology carried out in connection with hydro-electric development. Subsequently, he presented papers on this subject to the 1951 International Water Resources conference, held in Brussels, and to the 1954 conference in Tokyo.

In 1957 he represented New Zealand at the Bangkok conference on hydroelectric development, held under the auspices of the United Nations Economic Commisson for Asia and the Far East (ECAFE) and dealing principally with the assessment of hydro-electric potential in under-developed countries.

General Manager of Eurochemic

The European Company for the Chemical Processing of Irradiated Fuels (EUROCHEMIC) announces that, at a meeting of the Board of Directors held yesterday at the offices of the O.E.E.C. European Nuclear Energy

The President, Dr. Rajendra Prasad, inaugurating the 30th annual meeting of the Central Board of Irrigation and Power, at Vigyan Bhavan, New Delhi, on November 23. On the President's left is the Union Minister for Irrigation & Power, Hafiz Mohammed Ibrahim. Also to be seen are Mr. T. Sivasankar, I.C.S., Mr. M. Hayath, Prof. Thacker and Mr. Baleswar Nath, Secretary of the Board.

Agency, Dr. Erich Pohland, of the German Bundesministerium fur Atomkernenergie (German Federal Ministry for Atomic Energy) was appointed General Manager of the Company. Dr. Pohland was elected Chairman of the Board last July.

At the same meeting, Dr. R. Rometsch, formerly of the Swiss "CIBA" Company in Bale, was appointed Research Director of Eurochemic.

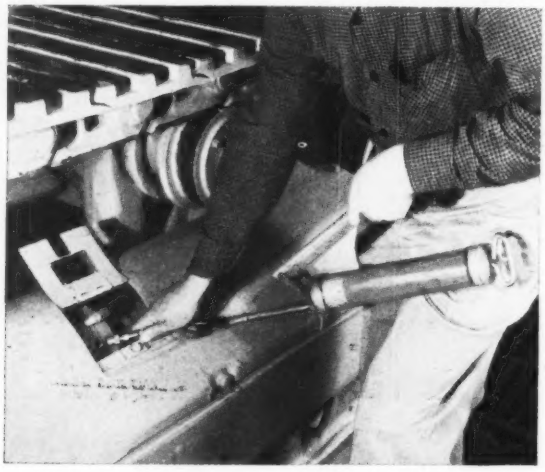
D. J. D. Sussex

Mr. D. J. D. Sussex took over recently from Mr. W. Brodbeck as the new All-India Manager of Agricultural & Construction Equipment Department of Voltas Limited.

Mr. Sussex started his career as a Sales Engineer with Massey Hariss Ltd. of Australia in 1928. At the beginning of the Second World War, he joined the infantry and saw active service in Europe where, during the historic Allied landings on the Normandy Beach in 1944, he worked with the Beach Clearance Group. He was mentioned twice in despatches and awarded the 'Croix de Guerre'. After the War, he set himself up as an industrial, constructional and sales consultant to a number of business and industrial firms in the U.K. and helped in the execution of many tough projects. Prior to joining Voltas, Mr. Sussex served as an Executive Survey Analyst with a firm of business efficiency specialists.

Hydraulic Track Adjuster

Increased ease of track adjustment on three Caterpillar built crawlers has been announced, with the introduction of hydraulic track adjusters as attachments for the Caterpillar D4 and D6 Tractors, and No 977 Traxcavators.



Previously introduced on Caterpillar's three largest track-type tractors, the new adjusters allow track tension to be adjusted with a standard hand-operated grease gun, and replace the former bolt-and-wrench system. The manufacturer claims prolonged track life as a benefit, since the new easier method encourages operators to correct track tension at proper intervals.

Editorial

Power Shortage

The Associated Chamber of Commerce took serious notice of the inadequacy of supply of power in many parts of the country in a resolution adopted in its annual meeting held recently. Power shortage has indeed become a serious problem for sometime and the Government should take note of it with a sease of urgency. The country has developed a tempo of economic growth and it would be positively damaging if the pace is retarded by inadequacy of power supply.

There was a time when considerable emphasis was laid on hydro-power. But it is evident that hydro-power is most suitable for peak-loads and suffers from the defect of fluctuating with the season. Therefore only when thermal power is combined with hydro-power is it possible to meet the ever-growing demand. It is, however, welcome that this shift in emphasis has now been taken note of by our experts.

New industries cannot be planned for and located in advance unless the fear of stoppages is removed and a steady supply of power is assured. Thus, the firm power must be on the shelf much in advance of the industries in order to promote their development.

In this connection it is also relevant to note that while the major hydro-projects are planned to produce a maximum quantum of energy, their *actual* annual average would be much less than that. For example, the turbines at Bhakra can only produce 53 mW at the minimum head while they can generate 90 mW at the maximum head. Again, the Kundah Project would generate about 129,000 kW all through the year instead of the planned 180,000 kW. Similarly the firm power in the Periyar project all the year round is estimated to be only 44,000 kW although the maximum capacity is 105,000 kW. The following passage from the Report of the Working Group of the Madras Government on power development in the third Five Year Plan is still more revealing.

"From this analysis it can be seen that though the installed capacity of the Grid amounted to 2,56,000kW in 1956, the effective capacity in terms of dependable firm power was much less, about 143,000 kW only. In exceptionally bad years of drought—and we had a succession of them in the recent past—or when the south-west monsoon is delayed, the storage in these reservoirs are exhausted, necessitating drastic power cuts. There were power cuts in 1953, 1956, 1957 and the one in 1958 went upto 75% during the month of June and practically paralysed all established industries in the hydro-electric area."

The recent experience of the operation of the sluice gates of the four dams in the DVC during the 1959 floods clearly indicates how the interests of flood control and power generation conflict at crucial moments. Possibly considerable power sto ppage would have been inevitable if the moderation of floods were to be achieved more effectively as there were not enough thermal units to switch on to. The Bokaro Station is already overworked and does not get even time for overhaul.

The study of the load demands in the coming few years in several zones shows that under the present plans of development, *even if they keep to their schedule* which is extremely unlikely, supply will not only not be able to keep pace with demand, but that the gap between the two may widen further. This is indeed a serious position. What does the Government propose to do in this respect? For, a clear understanding of Government plans is a necessary precondition for planning new industries or expansion of established ones by others.

Obviously the task is enormous. The Government has done a lot and is doing more. But the situation is overwhelming. Why should it not, in addition to its own efforts, encourage the existing supply undertakings to expand their units or even establish new ones ? The Government's policy of trying to keep power industry as much within the public sector as possible may be justifiable, but if this policy inhibits the growth of the industry at a pace required by the momentum of demand, should not the policy be refashioned to meet the more urgent needs of the country ?

The idea of setting up smaller thermal units mooted in the Chamber's meeting may sound nice but it is the larger and modern units that will be more economic and efficient and in harmony with India's plans for conservation of high grade coal.

Book Review

Irrigation Engineering by V.V. Priyani (4th Edition) published by Charotar Book Stall, Station Road, Anand, W. Rly. Pages 406, Price Rs. 15/-.

As we had occasion to review this book in its first edition we need not discuss it at length. Suffice it to say that it is a very well written basic text book for engineering students in the field of irrigation. The very fact that in the course of 4 years four editions have become necessary shows that the book has been well received and has fulfilled a great need. The usual chapters included in the previous editions are incorporated in this one. A fresh chapter on "Malaria Control" has been added. The appendices giving 29 photographs of irrigation structures further enhance the utility of the book for the students.

Problems in Engineering Structures by Ashby and Chilver, published by Edward Arnold Publishers Ltd. (Orient Longmans Private Ltd, agents in India) pages 168, Price 16 sh.

Fluid Mechanics for Engineering Student by J.R.D. Francis (Publishers same as above) pages 322, price 24 sh.

Engineering Thermodynamics: an Introductory Text. by D. P. Spalding and E. H. Cole, (Publishers same as above), Pages 375, price 28 sh.

The first book gives to the student of engineering structures an additional aid in the form of worked examples, indicating the steps in the solution. It covers some of the elementary aspects of structural analysis. The standard made at corresponds to the first two years of the University course. Nevertheless the importance of certain new fields of structural theory, such as plastic design, are also partly covered.

The book on Fluid Mechanics deals with a subject which is more difficult for the undergraduate engineer to master. It attempts to provide a simple yet up-to-date text book for the early part of degree course with the requirements of the London B. Sc. (Engineering) degree and the higher National Certificate in Engineering in mind.

Starting with the Properties of Fluids, and Forces in Static Fluids or on Immersed Objects, the different chapters included such topics as Curvature of Streamlines, Production of Shear Forces in Boundary Layers, Flow through Pipes and Closed Conduits, Flow in Open Channels. Hydraulic Machinery and Non-Steady Flow. The book would certainly be considered as a great help to the students of engineering.

The book on "Thermodynamics" has also been planned for a similar purpose. It is based on lectures given to first year engineering students at Cambridge University and is therefore concerned with fundamentals rather than applications, although attempt has been made to demonstrate the way in which the theoretical subtleties arise out of and a help to solve, practical engineering problems. We strongly recommend this book to the students of this subject.

Machine Shop Engineering Science by A. Oxley, published by Edward Arnold Publishers Ltd., (Orient Longmans Private Ltd., Agents for India), pages 215, price 7sh-6d.

The purpose of this book is to encourage apprentice fitters and machinists to take a technical interest in the science of the workshop. The book will be of special interest to students who are studying for the intermediate examinations in machine shop engineering. The approach of the author is more practical than academic and the text of each chapter is simple and brief. It is hoped that the new generation of technicians in our country will be greatly benefited from this book.

Principles of Electronics by M. R. Gavin and J. E. Houldin published by the Engineering Universities Press Ltd. (Agents in India : Orient Longmans Private Ltd), pages 348, price 30sh.

This is one of the series of books planned by the publishers. The Chief Editor of this series under the title "Physical Science Text" is Sir Graham Sutton. The object of the book under review is to give a general introduction to the subject of electronics suitable for a first degree or diploma course in physics or electrical engineering. Emphasis is laid on the principles of operation of valves, transistors and other electronic devices and of the conduits in which they are used. The idea is to provide a general background that is essential prior to specialisation in any particular branch of electronics.

Principles of Alternating Currents (2nd Edition) by W. Slucking and J. R. Greener published by Cleaver-Hume Press Ltd. (Agents in India : Orient Longmans Private Ltd.) Pages 338, Price 15 sh.

This second edition of the book has undergone considerable revision. But the principal objective—that of providing a self-contained text using a minimum of mathematical tools yet explaining the basic theory of alternating current has been preserved. No previous knowledge of the subject is assumed other than some familiarity with electricity and magnetism at an entirely elementary level.

Our Contributors

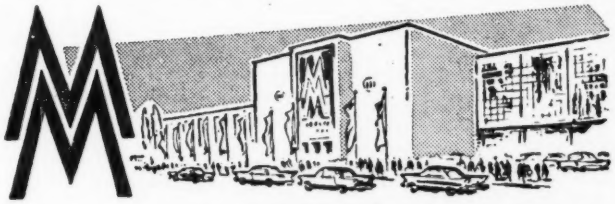
Mr. Eugene R. Black is President of the International Bank for Reconstruction and Development popularly known as the World Bank, and needs hardly any introduction to those who are connected with development projects in underdeveloped countries.

Mr. A. G. Mirajgaokar graduated in 1951 from Osmania University and received his M. E. from the University of Roorkee in 1957. A. M. I. E. and M. I. A. H. R. He is working as lecturer in Civil Engineering at Roorkee; at present in the United States under T. C. M. Scholarship programme for higher studies in Irrigation and Drainage Engineering.

Mr. C. S. Parthasarathy also has been a frequent ontributor.

Mr. D. K. Jain qualified himself as a Mechanical Engineer from Technical Institute, Baroda in 1927 and passed as First Class Engineer of Competency of the Punjab Government (Boiler) in the same year. Elected as Assoc. Mem of Am. Soc. of Mech. Engineers, he worked for 20 years as Factory Engineer in numerous sugar factories and thermal power plants. Worked for over 5 years in the Punjab Irrigation Branch and was engaged in erection of Gates of Harike Barrage and Madhopur Head and of Gates and Gearing and Penstocks of Kotla Power House. He had also experience of inspection and fabrication and installation of penstocks in the Bhakra Dam, working as J. Specialist (Mech).

Mr. S. Szafranski has been a frequent contributor to our journal.



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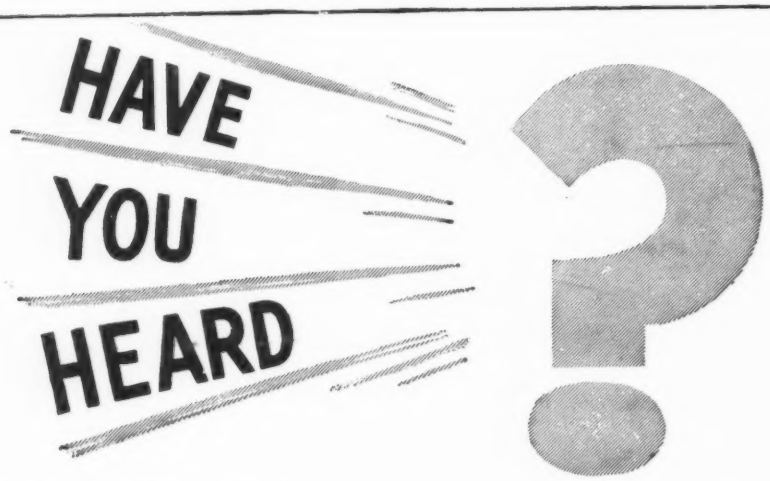

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